

APPENDIX B-I

HEALTH EFFECTS OF CONTAMINANTS

The information in this sheet applies to workplace exposure resulting from processing, manufacturing, storing or handling and is not designed for the population at large. Any generalization beyond occupational exposures should not be made. The best industrial hygiene practice is to maintain concentrations of all chemicals at levels as low as is practical.

Chemical Names: Propanone, dimethylketone, beta-ketopropane; CAS 67-64-1.

Trade Names: None found.

Uses: A solvent for paints, plastics and rubber; general cleaning agent for oils and greases; intermediate in the production of ketones.

PHYSICAL INFORMATION

Appearance: Clear, colorless liquid.

Odor: Pungent.

Minimum Detectable by Odor: 47 ppm.

Behavior in Water: Soluble.

Evaporation: Rapid.

HEALTH HAZARD INFORMATION

OSHA Standard: Average 8 hour exposure -- 1,000 ppm.

NIOSH Recommended Limit: Average 8 hour exposure -- 250 ppm.

ACGIH Recommended Limit: Average 8 hour exposure -- 750 ppm.

Short Term Exposure:

Inhalation: Levels of 300 ppm have caused irritation of eyes, nose and throat. Levels of 500 to 1,000 ppm for 6 hours have caused, in addition, general weakness and heaviness of the eyelids. Exposures of 12,000 ppm for a few minutes may cause weakness in arms and legs and fainting. 20,000 ppm may be fatal on brief exposure.

Skin: Liquid acetone may cause drying of the skin, irritation, redness, and an increased chance of infection.

Eyes: Irritation has been reported at 500 ppm after 3-6 hours. Splashes into the eye may result in swelling, irritation, damage to the cornea and blindness.

Ingestion: 20 ml (2/3 fluid ounce) may result in excess salivation, nausea, vomiting, stomach pain and possible liver and kidney damage. 200 ml (7 fluid ounces) has resulted in these symptoms and, additionally, swelling of the throat, sores in the mouth and throat, shallow breathing and coma. Although 200 ml has been survived with prompt medical attention, death may occur from as little as 100 ml (3½ fluid ounces).

Long Term Exposure:

Levels of 500 to 1,000 ppm can produce eye irritation after 3 hours. Daily exposures at this level have resulted in irritation of throat and lungs, dizziness, and inflammation of stomach and intestines.

*Prepared by the Bureau of Toxic Substance Assessment, New York State Department of Health. For an explanation of the terms and abbreviations used, see "Toxic Substances: How Toxic is Toxic" available from the New York State Department of Health.

EMERGENCY AND FIRST AID INSTRUCTIONS

Inhalation: Move victim to fresh air. Administer oxygen or artificial respiration as required. Seek medical attention, if necessary.

Skin: Remove soaked clothing. Wash affected area with large amounts of water. Seek medical attention, if required.

Eyes: Wash with large amounts of water immediately. Seek immediate medical attention.

Ingestion: Seek immediate medical attention.

Note to Physician: Blood, urine and expired air analysis have been used as an index of exposure.

FIRE AND EXPLOSION INFORMATION

General: Highly flammable; can form explosive mixtures in air. Will ignite at 0°F (-18°C).

Explosive Limits: Upper - 13%, lower - 2.1%.

Extinguisher: Carbon dioxide, dry chemical or alcohol foam.

REACTIVITY

Conditions to Avoid: Heat and flame.

Materials to Avoid: Violent and explosive reactions may occur when acetone contacts potassium tert-butoxide, sulfuric acid-dichromate solution, or chloroform in the presence of a strong base (i.e., potassium hydroxide). May react violently with oxidizing agents such as chlorine, permanganate, dichromate or peroxides.

PROTECTIVE MEASURES

Storage and Handling: Store in cool, ventilated area away from fire hazard. Acetone will dissolve plastic items such as eyeglass frames pens and pencils, and some synthetic fabrics such as rayon.

Engineering Controls: Provide adequate ventilation. Sinks, showers and eyewash stations should be available.

Protective Clothing (Should not be substituted for proper handling and engineering controls): Wear rubber gloves, apron and goggles that are impervious to acetone if contact with acetone is likely.

Protective Equipment: For levels up to 2,500 ppm, use a gas mask with an organic vapor canister, a Type C supplied-air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. For levels greater than 2,500 ppm, use a self-contained breathing apparatus with a full facepiece in a positive pressure mode or a combination Type C supplied-air respirator with a full facepiece in pressure-demand mode with a positive pressure auxiliary air supply.

PROCEDURES FOR SPILLS AND LEAKS

Get all workers out of spill area. Put on respirator and other protective clothing. Eliminate sources of flame. Ventilate area to remove fumes and maintain levels below explosive limits. For final disposal, contact your regional office of the New York State Department of Environmental Conservation. For more information: Contact the Industrial Hygienist or Safety Officer at your worksite or the New York State Department of Health, Bureau of Toxic Substance Assessment, Empire State Plaza, Tower Building, Albany, New York 12237.

BENZENE

Executive Summary

CAS NUMBER: 00071-43-2

Benzene is a clear, colorless, highly flammable liquid. It is a nonpolar solvent with an odor characteristic of aromatic hydrocarbons. Produced commercially from coal since 1948 and from petroleum since 1941, benzene is currently produced in the U.S. by the catalytic reforming of petroleum. Fifty percent of all benzene produced is used in gasoline. The primary interest in benzene is its toxicity to man. Federal regulations require the reporting of all benzene spills exceeding 1000 pounds (454 kilograms) or 136 gallons (515 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Benzene causes acute toxic effects on the central nervous system. The primary route of exposure is by inhalation. Single exposures to benzene in the air at 20,000 ppm have proven fatal within 50 to 10 minutes. Death is usually due to respiratory or cardiac failure. At lower levels, headaches, nausea, staggering gait, paralysis, convulsions, and unconsciousness are observed.

CARCINOGENICITY. There is substantial epidemiological evidence that benzene may cause leukemia in humans. However, no validated animal model has yet been developed for benzene as a carcinogen. Benzene has been designated an industrial substance suspect of carcinogenic potential by ACGIH.

MUTAGENICITY. Ample evidence exists that benzene exposure causes chromosomal aberrations in animals and humans which are probably heritable if they occur in the germinal cells. EPA (Carcinogen Assessment Group) suggests that somatic mutations may occur at benzene concentrations as low as 1 ppm in air.

TERATOGENICITY. While some animal studies have reported a teratogenic effect, a Consumer Product Safety Commission review concluded that existing animal data do not show benzene to be a teratogen.

CHRONIC. The health effects of chronic exposure to benzene are by far the most serious of any of the common hydrocarbon solvents. Benzene has been shown to cause leukemia, destroy large red blood cells, reduce the white blood cell count and cause aplastic anemia. Most deaths have resulted from exposures to levels exceeding 200 ppm, though blood changes have been reported in workers exposed at levels below 100 ppm. Workers exposed to benzene concentrations between 300 and 700 ppm consistently show marked blood disorders.

Liquid benzene on the skin may cause erythema and blistering, and a dry scaly dermatitis may develop on prolonged or repeated exposure. If accidentally ingested, benzene may cause ulceration of the gastrointestinal mucosa.

Occupational Health

The American Conference of Governmental Industrial Hygienists (ACGIH) has established a

Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (30 mg/cu m). This is the same as the current OSHA standard for a time-weighted average. However, OSHA issued a more stringent standard of 1 ppm in 1977, but this was revoked by court in 1981.

Routes of Human Exposure

OCCUPATIONAL. It has been estimated that 65% of all benzene used in the U.S. is in the production of ethylbenzene and phenol. Workers in these industries are at high risk of exposure. The National Institute for Occupational Safety and Health (NIOSH) requires that every worker subject to exposure to benzene must have urine sampling and analysis at quarterly intervals.

AMBIENT. EPA has assigned priorities to atmospheric sources of benzene emission:

High priority sources -

- Ethylbenzene/styrene manufacture
- Coke by-product plant
- Benzene storage vessels
- Maleic anhydride plants
- Chemical plants/petroleum refinery fugitive emissions

Low priority sources -

- Gasoline Marketing (service stations)
- Other chemical plants (ethylene, chlorobenzene, nitrobenzene, alkyl benzenes, etc.)
- Solvent users (rubber product manufacturing, adhesives, inks, paints).

CONSUMER. Along with ambient air exposures (self-service gasoline delivery), cigarettes (average 90 micrograms per cigarette) and food appear to constitute the major exposure routes to benzene for the general population. While data on benzene in food are limited, the chemical has been detected in nearly all major food categories. It has also been detected in municipal tap water at 0.1 to 0.3 mg/liter.

Environmental Significance

The half-life of benzene in air is estimated to be 7 days and between one hour and 1 week in environmental waters. A bioconcentration factor of 5.21 has been calculated on the basis of the octanol/water partition coefficient.

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 5.3 mg/l and to saltwater aquatic life at concentrations as low as 5.1 mg/l. Sensitive species may suffer toxic effects at lower concentrations. Adverse effects can occur to fish species at concentrations as low as 0.7 mg/l exposed for 165 days. Aquatic algae are less sensitive to benzene than are most fish.

Soils serve as a major sink for atmospheric benzene but plant uptake is negligible. Releases of benzene to water and land (via air, 10% or less) compared with releases to air.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

BENZENE

North Carolina Production and Users

Production: One North Carolina producer reported (TSCA Chemical Substances Inventory): Morganton Plastics, Morganton: 0.55.0 tons/year.

Users: No information available

Recommended Reviews

Carcinogen Assessment Group's Final Report on Population Risk to Ambient Benzene Exposures. U.S. EPA, Carcinogen Assessment Group (February, 1980).

NTP Technical Bulletin. Vol. 1, Issue 3. National Toxicology Program, Department of Health and Human Services (December, 1980).

EPA Information Paper on Benzene. U.S. EPA, Office of Research and Development (December 19, 1980).

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH BENZENE.

Skin: Wash the contaminated skin promptly with soap or mild detergent and water. Remove clothing if contaminated and wash skin.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Do not induce vomiting. Seek immediate medical attention.

Environmental Spills (U.S. Department of Transportation Emergency Response Guidebook, 1980)

Will burn: No flares, smoking or flames.

Fires: Water spray, fog or alcohol foam.

Use water spray to reduce vapors.

Small spills: Take up with sand or other noncombustible absorbent material, then flush area with water.

Large spills: Dike far ahead of spill for later disposal.

The North Carolina Toxic Substances Management Guide

BENZENE

Profile

Chemical Identification

Alternative Names:

Benzin	Mineral Naphtha
Benzine	Motor Benzol
Benzol	NCI-C55276
Benzole	Nitration Benzene
Benzolene	Phene
Bicarburet of Hydrogen	Phenyl Hydride
Carbon Oil	Pyrobenzol
Coal Naphtha	Pyrobenzole
Cyclohexatriene	

Chemical Abstract Services (CAS) Registry
Number: 00071-43-2

Registry of Toxic Effects of Chemical Substances
(RTECS) Number: CY140000

Hazardous Materials Table Identification
Number: UN 1114

RCRA Identification Number: U 019

Molecular Weight: 78.12

Molecular Formula: C₆H₆



Classification: The simplest aromatic compound

Description: A clear, colorless, highly flammable liquid. It is a nonpolar solvent with an odor characteristic of aromatic hydrocarbons.

Uses: In the manufacturing of detergents, organic chemicals, pesticides, synthetic rubber, aviation fuel, dyes, explosives and in the processing of nylon.

Chemical/Physical Data

Boiling point: 80.1°C
Melting point: 5.5°C
Vapor pressure: 92.5 mm at 25°C
Vapor density: 2.77 (air = 1.0)
Solubility in water: 800 mg/l at 20°C

HUMAN TOXICITY

The summary provided below is from an EPA Agency-wide Chemical Information paper (EPA, ORD, 1980).

Acute--Acute benzene poisoning is characterized by nausea, vomiting, ataxia (muscular incoordination) and excitement followed by depression and coma. Death is usually the result of respiratory or cardiac failure. Benzene exposure causes acute toxic effects on the central nervous system. Single

exposures of benzene in the air at a concentration of 20,000 ppm have proved to be fatal within 5 to 10 minutes. Effects include headaches, nausea, staggering gait, paralysis, convulsions, and eventual unconsciousness and death, usually following cardiovascular collapse. Giddiness and euphoria have also been reported. Severe nonfatal cases have exhibited similar symptoms but recovered after a period of unconsciousness. Accidentally ingested benzene may result in ulceration of the gastrointestinal mucosa.

Chronic--Multiple exposures over time can cause leukemia. Benzene destroys red blood cells. It reduces the white blood cell count. A more severe result is known as aplastic anemia in which the blood producing cells of the bone marrow are severely reduced.

Additional information on toxic effects and concentrations have been noted by NIOSH and are summarized below.

The chronic exposure effects of benzene are by far the most serious disease caused by any of the common hydrocarbon solvents. Most deaths have resulted from exposures to levels exceeding 200 ppm. Blood changes are reported in workers exposed at levels below 100 ppm (ACGIH, 1980). Worker exposures to benzene concentrations between 300 and 700 ppm consistently showed marked blood dyscrasias (NIOSH, 1974).

Liquid benzene on the skin may cause erythema and blistering, and a dry, scaly dermatitis may develop on prolonged or repeated exposure. The rate of benzene absorption through the intact human skin is reported to be 0.4 mg/cm²/hr. Skin absorption is not considered to be an important route of entry (NIOSH, 1974).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 2,000 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980 CAG concluded that there is substantial epidemiological evidence that benzene is a human leukemogen. CAG estimates that the number of cases of leukemia per year in the general population due to ambient atmospheric benzene is about 90. (The 95 percent confidence interval is from 34 to 235.) This is between 0.23 and 1.62 percent of the total leukemia deaths in the U.S. based on statistics from 1973.

IARC, 1974 It is established that exposure to commercial benzene or benzene-containing mixtures may result in damage to the hematopoietic system. A relationship between such

exposure and the development of leukemia is suggested by many case reports, and this suggestion is strengthened by a case-control study from Japan. Benzene has been tested only in mice by subcutaneous injection and skin application. The data reported do not permit the conclusion that carcinogenic activity has been demonstrated.

Mutagenicity

U.S. EPA, CAG, 1979 CAG concluded that ample evidence exists that benzene causes chromosomal aberrations in animals and humans exposed. These chromosomal aberrations probably involve breaks in DNA and therefore are probable heritable events if they occur in the germinal cells, although the experiments have not been decisive. At the current time, quantitative estimates of heritable genetic damage due to benzene cannot be made from data on the frequency of somatic mutations, although this damage may be occurring at concentrations as low as 1 ppm in air.

Teratogenicity & Embryotoxicity

Shepard, 1980 Injections (3 ml/kg on the 13th day of gestation) resulted in increased incidence of cleft palate and mandible reduction in mice. Skeletal growth retardation and skeletal anomalies were observed in offspring of rats exposed to high concentrations (up to 2,000 ppm) during pregnancy. No developmental malformations were found when pregnant rats were exposed continuously to benzene vapors (1 to 670 mg/cu m). The number of fetuses was reduced with the higher concentrations.

ANIMAL TOXICITY

Many studies on the effects of benzene exposure on laboratory animals have been performed. Toxic effects have been observed in the bone marrow, blood (leukopenia), testes (degeneration of the seminiferous vesicles), central nervous system (decreased reflex activity, depression, sedation), behavior (decreased spontaneous behavior), and reduced resistance to infection (NIOSH, 1974).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	3,800 mg/kg, LD50
	Mouse	4,700 mg/kg, LD50
	Dog	2,000 mg/kg, lowest lethal dose

Lethal Studies (Continued)

Inhalation	Rat	10,000 ppm (32,600 mg/cu m), for 7 hours. LC50
	Mouse	9,980 ppm (32,535 mg/cu m), LC50 (duration not given)
	Dog	4,520 ppm (14,600 mg/cu m), lowest lethal level (duration not given)

Chronic Toxicity

A rat inhalation study resulted in the development of a moderate degree of leukopenia after 5 to 8 weeks of 5 hr/day, 5 days/week exposure at 44 and 47 ppm. No effects were observed at exposures of 15 to 31 ppm. Rats displayed a decrease in the white blood cell counts following 756-hr. exposure at 50 ppm for 8 hr/day, 5 days/week. Observations included reduced amounts of DNA in the white cells, a depression in myelocytic activity and an increase in the red cell precursors in bone marrow (ACGIH, 1980).

Aquatic Toxicity

Aquatic toxicity rating: TLM is 10-100 (RTECS, 1980)

The EPA water quality criteria for protection of aquatic life are as follows:

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 5.3 mg/l. Sensitive species encounter toxic effects at lower concentrations. Acute toxicity to saltwater aquatic life occurs at concentrations as low as 5.1 mg/l. Adverse effects occur at concentrations as low as .7 mg/l with a fish species exposed for 168 days (U.S. EPA, WQC, 1980).

Aquatic algae are less sensitive to benzene than are most fish (U.S. EPA, ORD, 1980).

No information was found regarding bioaccumulation or biodegradation in aquatic species. An average bioconcentration potential of 5.21 was estimated in developing the water quality criteria. This level is not considered significant (U.S. EPA, ORD, 1980).

ENVIRONMENTAL DATA

Air

The average ambient air level of benzene is estimated to be 3.26 ug/cu m or 10 ppb (U.S. EPA, WQC, 1980). Concentrations ranging from 50 ug/cu m to 200 ug/cu m (0.015-0.05 ppm) have been detected in Los Angeles air (IAP, 1975). Benzene has an estimated half-life in air of 20-50 min, calculated from smog chamber data (U.S. EPA, WQC, 1980), and degrades rather rapidly in the atmosphere. Accumulation in air over urban areas can be significant, up to 100 times greater than normal background levels (U.S. EPA, WQC, 1980).

Water

Benzene has been detected in finished drinking water at 0.1 to 0.3 µg/l and in water and sediment samples from the lower Tennessee River in ppb concentrations (U.S. EPA, WQC, 1980). This compound has an estimated half-life in water of 1 hour to 1 week (U.S. EPA, ORD, 1980), and little accumulation in this medium is expected. Soluble benzene persists in water until slow biodegradation occurs.

Soil

There are limited data regarding the persistence of benzene in the soil. This compound probably volatilizes before degradation can occur, but could also biodegrade slowly (Callahan, 1979). Soil may act as a "sink" for atmospheric benzene, resulting in some accumulation (U.S. EPA, ORD, 1980).

Biota

Although limited information is available regarding benzene's persistence in biota, degradation in this medium appears likely (Callahan, 1979). Slow bacterial degradation and a low octanol/water partition coefficient make accumulation unlikely. Biomagnification is not expected.

Benzene occurs in straight-run petroleum distillates and in coal-tar distillates. Motor gasolines are reported to contain small quantities of benzene, usually less than 5 percent, (IARC, 1974), although benzene content in leadfree gasolines may be much higher (up to 30%) (IARC, 1975). It has been detected in several foods including fruits, nuts, vegetables, dairy products, meats, fish, poultry and several beverages. Cigarettes are also estimated to contain benzene at 90 µg/cigarette (U.S. EPA, ORD, 1980).

INDUSTRIAL DATA

Production

Production in North Carolina was reported by 1 company in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Morganton Plastics, Morganton; 0.5-5.0 tons/year (U.S. EPA, TSCA Inventory, 1980).

Benzene production and importation was estimated at over 11 million metric tons in 1980 (U.S. EPA, ORD, 1980).

Consumption and Use

Estimated U.S. Consumption:

Chemical intermediate for ethylbenzene	42 percent
Chemical intermediate for phenol	23 percent
Chemical intermediate for cyclohexane	13 percent

Estimated Consumption (Continued)

Chemical intermediate for maleic anhydride	4 percent
Chemical intermediate for detergent alkylate	4 percent
Chemical intermediate for aniline	4 percent
Miscellaneous uses (MEDLARS, 1981)	8 percent

Reported uses of benzene and the corresponding Standard Industrial Classification Codes are listed below:

	<u>SIC</u>	<u>Reference</u>
Chemical intermediate for ethyl benzene, phenol, cyclohexane, maleic anhydride, and aniline	2869	TDB, 1981
Chemical intermediate for detergent alkylate	284	
In manufacture of dichlorobenzenes, anthraquinone, benzene hexachloride, and biphenyl	2869	
In manufacture of chlorobenzene and DDT	287	
Manufacture of medicinal chemicals	283	
Manufacture of dyes	2865	
Manufacture of linoleum	3996	
Manufacture of varnish and laquers	2851	
Manufacture of oil cloth		
Manufacture of airplane dope		
As a solvent for waxes and resins		
Constituent for motor fuels		

Sources of high benzene emissions to the atmosphere have been assigned priorities by the U.S. Environmental Protection Agency.

High Priority Sources

Ethylbenzene/styrene manufacture
Coke by-product plants
Benzene storage vessels
Maleic anhydride plants
Chemical plants/petroleum refinery fugitive emissions

Low Priority Sources

Gasoline marketing
Other chemical plants (ethylene, chlorobenzene, nitrobenzene, alkyl benzenes, etc.)
Solvent users (Rubber product manufacturing, adhesives, inks, paints) (U.S. EPA, ORD, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Designated a hazardous air pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (30 mg/cu m) as a time-weighted average and the short term exposure limit is 25 ppm (75 mg/cu m). Benzene is designated an "Industrial Substance Suspect of Carcinogenic Potential for Man".

NIOSH The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 1 ppm (3 mg/cu m) as a time-weighted average and a ceiling limit of 5 ppm (15 mg/cu m). NIOSH considers the evidence to be conclusive that benzene is leukemogenic and recommends that exposure to benzene be kept as low as possible.

OSHA The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 10 ppm (30 mg/cu m) as a time-weighted average. The standards represent allowable concentrations of toxic or hazardous substances to which employees may be exposed without incurring adverse health effects. A more stringent standard reflecting the risk of leukemia from benzene was set at 1 ppm (3 mg/cu m) as a time-weighted average and a ceiling of 5 ppm (15 mg/cu m), but this standard was revoked by court action (Code of Federal Regulations, Title 24, Part 1910, Subpart Z).

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Benzene is classified as a flammable liquid and shipments must carry this label.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency. The regulations address the proper management of hazardous wastes.

Institutions Concerned with this Chemical

Appears on the 1978 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group.

Tested by the National Cancer Institute (NCI) for carcinogenicity. (National Toxicology Program, Fiscal Year 1980 Annual Plan. NTP-79-7 (1979)).

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Occupational Health Guideline for Butyl Acetate

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $\text{CH}_3\text{COO}(\text{CH}_2)_3\text{CH}_3$
- Synonyms: n-Butyl acetate; butyl ethanoate; acetic acid butyl ester
- Appearance and odor: Colorless liquid with a fruity odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for butyl acetate is 150 parts of butyl acetate per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 710 milligrams of butyl acetate per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

• Routes of exposure

Butyl acetate can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed.

• Effects of overexposure

1. **Short-term Exposure:** Overexposure to butyl acetate may cause irritation of the eyes, nose, and throat. Severe overexposure may cause weakness, drowsiness, and unconsciousness.

2. **Long-term Exposure:** Prolonged overexposure may produce irritation of the skin.

3. **Reporting Signs and Symptoms:** A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to butyl acetate.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to butyl acetate at potentially hazardous levels:

1. **Initial Medical Screening:** Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from butyl acetate exposure.

—Skin disease: Butyl acetate is a mild defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Kidney disease: Although butyl acetate is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with possible impairment of renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of butyl acetate might cause exacerbation of symptoms due to its irritant properties.

—Liver disease: Although butyl acetate is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

2. **Periodic Medical Examination:** Any employee developing the above-listed conditions should be referred for further medical examination.

• Summary of toxicology

The principal effect of overexposure to butyl acetate is irritation of the eyes and nose, which occurs at 200 to 500 ppm and is marked at concentrations over 3000 ppm. Butyl acetate splashed in the eye causes marked irritation, but recovery is rapid. Anesthetic effects have been observed in animals at very high concentrations. Levels of 400 to 600 ppm in exposures of 2 to 3 hours' duration did not cause anesthetic effects in man. No chronic systemic effects have been reported in humans.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 116
2. Boiling point (760 mm Hg): 126 C (260 F)
3. Specific gravity (water = 1): 0.88
4. Vapor density (air = 1 at boiling point of butyl acetate): 4.0
5. Melting point: -74 C (-101 F)
6. Vapor pressure at 20 C (68 F): 10 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.68
8. Evaporation rate (butyl acetate = 1): 1.0

• Reactivity

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with nitrates, strong oxidizers, strong alkalis, and strong acids may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving butyl acetate.

4. Special precautions: Butyl acetate will dissolve many plastics and resins.

• Flammability

1. Flash point: 22 C (72 F) (closed cup)
2. Autoignition temperature: 425 C (797 F)
3. Flammable limits in air, % by volume: Lower: 1.7; Upper: 7.6

4. Extinguishant: Dry chemical, carbon dioxide, foam

• Warning properties

1. Odor Threshold: Summer and May report odor thresholds for butyl acetate of 7 ppm and 20 ppm, respectively.

2. Eye Irritation Level: Grant reports that the vapor of butyl acetate "causes irritation of the eyes and nose, first noticeable to human beings at a concentration of 300 ppm in air, and objectionable at 3300 ppm; higher concentrations cause tearing and hyperemia of the conjunctiva."

3. Evaluation of Warning Properties: Butyl acetate can be detected below the TLV through its odor, and at a concentration of only twice the TLV through its irritant effects. For the purposes of this guideline, therefore, butyl acetate is considered to have good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

Sampling and analyses may be performed by collection of butyl acetate vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure butyl acetate may be used. An analytical method for butyl acetate is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid butyl acetate.

• Clothing wet with liquid butyl acetate should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of butyl acetate from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the butyl acetate, the person performing the operation should be informed of butyl acetate's hazardous properties.

• Any clothing which becomes wet with liquid butyl acetate should be removed immediately and not reworn until the butyl acetate is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid butyl acetate may contact the eyes.

SANITATION

- Skin that becomes wet with liquid butyl acetate should be promptly washed or showered with soap or mild detergent and water to remove any butyl acetate.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to butyl acetate may occur and control methods which may be effective in each case:

Operation	Controls
Use during application of nitrocellulose by spraying, brushing, or dipping	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use during application of surface coatings other than nitrocellulose lacquers, including paper coatings, leather coatings, and airplane dope enamel	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation during manufacture of nitrocellulose lacquers	Local exhaust ventilation
Liberation during production of lacquer thinner	General dilution ventilation
Liberation during use as a solvent for oils, pitch, camphor, ethyl cellulose acetate, and chlorinated rubber	General dilution ventilation
Liberation during use as a solvent in production of artificial leather	General dilution ventilation
Liberation during use of protective coatings in automobile industry	Local exhaust ventilation
Liberation during use as a solvent for vinyl, polystyrene, and methacrylate plastics	Local exhaust ventilation
Liberation during manufacture of safety glass; during production of flavorings and perfumes; during manufacture of cosmetics, adhesives, shoe polishes, and stain removers	Local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If butyl acetate gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If butyl acetate gets on the skin, promptly flush the contaminated skin with water. If butyl acetate soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

• Breathing

If a person breathes in large amounts of butyl acetate, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When butyl acetate has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If butyl acetate is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Burn in a safe place (such as a fume hood) for sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a safe location away from combustible materials. Small quantities can be collected and atomized in a suitable combustion chamber. Butyl acetate should not be allowed to

enter a confined space, such as a sewer, because of the possibility of an explosion.

- Waste disposal methods:

Butyl acetate may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Butyl Acetate." *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

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RESPIRATORY PROTECTION FOR BUTYL ACETATE

Condition	Minimum Respiratory Protection* Required Above 150 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style organic vapor canister.
7500 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
10,000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 10,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used

Occupational Health Guideline for Ethyl Acetate

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $\text{CH}_3\text{COOC}_2\text{H}_5$
- Synonyms: Acetic ester; acetic ether; ethyl ethanoate
- Appearance and odor: Colorless liquid with a pleasant, fruity odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for ethyl acetate is 400 parts of ethyl acetate per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 1400 milligrams of ethyl acetate per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

• Routes of exposure

Ethyl acetate can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed.

• Effects of overexposure

1. **Short-term Exposure:** Overexposure to ethyl acetate may cause irritation of the eyes, nose, and throat. Severe overexposure may cause weakness, drowsiness, and unconsciousness.
2. **Long-term Exposure:** Prolonged overexposure may produce irritation of the skin.
3. **Reporting Signs and Symptoms:** A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to ethyl acetate.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to ethyl acetate at potentially hazardous levels:

1. **Initial Medical Screening:** Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from ethyl acetate exposure.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of ethyl acetate might cause exacerbation of symptoms due to its irritant properties.

—Skin disease: Ethyl acetate is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although ethyl acetate is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although ethyl acetate is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

2. **Periodic Medical Examination:** Any employee developing the above-listed conditions should be referred for further medical examination.

• Summary of toxicology

Ethyl acetate vapor is irritating to the eyes and respiratory passages of man at concentrations above 400 ppm. In animals it has a narcotic effect at concentrations of over 5000 ppm. Due to its irritating properties, employees will not voluntarily remain in such high concentrations. Repeated exposures of rabbits to 4450 ppm for 1 hour daily for 40 days resulted in anemia with leukocytosis, and damage to liver and kidneys. Animals exposed to lethal concentrations died with pulmonary edema.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

and hemorrhage. This substance is a defatting agent, and prolonged exposure may cause irritation of the skin. Painful conjunctival irritation may occur from splashes in the eye. No chronic systemic effects have been reported in humans.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 88
2. Boiling point (760 mm Hg): 77 C (171 F)
3. Specific gravity (water = 1): 0.9
4. Vapor density (air = 1 at boiling point of ethyl acetate): 3.0
5. Melting point: -83 C (-117 F)
6. Vapor pressure at 20 C (68 F): 76 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 8.7
8. Evaporation rate (butyl acetate = 1): 6

• Reactivity

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with nitrates, strong oxidizers, strong alkalis, or strong acids may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving ethyl acetate.
4. Special precautions: Ethyl acetate will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Flash point: -4.4 C (24 F) (closed cup)
2. Autoignition temperature: 427 C (800 F)
3. Flammable limits in air, % by volume: Lower: 2.2; Upper: 11
4. Extinguishant: Alcohol foam, carbon dioxide, dry chemical

• Warning properties

1. Odor Threshold: May and Summer report odor thresholds for ethyl acetate of 0.0056 ppm and 50 ppm, respectively.
2. Eye Irritation Level: Grant states that "a concentration of 400 ppm in air causes a sensation of irritation in human eyes." Animals exposed to much higher concentrations developed no corneal damage, only conjunctival irritation.
3. Evaluation of Warning Properties: Through its odor and irritant effects, ethyl acetate can be detected below or at the permissible exposure limit. For the purposes of this guideline, ethyl acetate is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30

minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

Sampling and analyses may be performed by collection of ethyl acetate vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure ethyl acetate may be used. An analytical method for ethyl acetate is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid ethyl acetate.
- Clothing wet with liquid ethyl acetate should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of ethyl acetate from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the ethyl acetate, the person performing the operation should be informed of ethyl acetate's hazardous properties.
- Any clothing which becomes wet with liquid ethyl acetate should be removed immediately and not reworn until the ethyl acetate is removed from the clothing.

- Employees should be provided with and required to use splash-proof safety goggles where liquid ethyl acetate may contact the eyes.

SANITATION

- Skin that becomes wet with liquid ethyl acetate should be promptly washed or showered to remove any ethyl acetate.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to ethyl acetate may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during use of shellacs, lacquers, dopes, varnishes, and stains	Local exhaust ventilation; general dilution ventilation
Liberation during manufacture of smokeless powder; during manufacture of artificial leather; during preparation of photographic films	Process enclosure; general dilution ventilation
Liberation and use as a solvent during application of coatings containing nitrocellulose, cellulose acetate, shellac, synthetic rubber, vinyl resins, and inks	Process enclosure; general dilution ventilation
Use as a cleaning agent in textile industry	Process enclosure; general dilution ventilation
Liberation during manufacture of photographic film	Process enclosure; general dilution ventilation
Liberation during manufacture of linoleum and plastic wood; during manufacture of dyes, drug intermediates, ethyl acetoacetate, etc.; during use of duplicator fluid	Process enclosure; general dilution ventilation
Liberation during use of varnish removers	General dilution ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If ethyl acetate gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If ethyl acetate gets on the skin, promptly flush the contaminated skin with water. If ethyl acetate soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

• Breathing

If a person breathes in large amounts of ethyl acetate, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When ethyl acetate has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If ethyl acetate is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Ethyl acetate should not be allowed

to enter a confined space, such as a sewer, because of the possibility of an explosion.

- Waste disposal methods:

Ethyl acetate may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR ETHYL ACETATE

Condition	Minimum Respiratory Protection* Required Above 400 ppm
Vapor Concentration	
1000 ppm or less	Any chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style organic vapor canister.
10,000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 10,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

ETHYL ALCOHOL

The information in this sheet applies to workplace exposure resulting from processing, manufacturing, storing or handling and is not designed for the population at large. Any generalization beyond occupational exposures should not be made. The best industrial hygiene practice is to maintain concentrations of all chemicals at levels as low as is practical.

Chemical Names: Ethanol, hydroxyethane, ethylhydroxide, methyl carbinol; CAS 64-17-5.

Trade Names: Grain alcohol, Algrain, Jaysol, Denatured Alcohol, and others.

Uses: Industrial solvent; in alcoholic beverages, colognes, tonics, and lotions; as a cleaning agent.

PHYSICAL INFORMATION

Appearance: Clear, colorless liquid. May be found in pure form or in various more dilute concentrations.

Odor: Pleasant, sweet, fruity.

Minimum Detectable by Odor: 5 ppm.

Behavior in Water: Soluble.

Evaporation: Moderate.

HEALTH HAZARD INFORMATION

OSHA Standard: Average 8 hour exposure -- 1000 ppm.

NIOSH Recommended Limit: None established.

ACGIH Recommended Limit: Average 8 hour exposure -- 1000 ppm.

Short Term Exposure:

Inhalation: Levels of 5000 ppm to 10,000 ppm may result in irritation of mouth, nose and throat and coughing, leading to sleep and stupor.

Skin: Pure ethyl alcohol may cause drying, redness and irritation. May be absorbed through damaged skin.

Eyes: Irritation and tearing may result at 5000 ppm of vapor. Contact with liquid may cause severe irritation.

Ingestion: One ounce of pure ethyl alcohol may cause reddening of face and neck and an exaggerated feeling of well-being. Three ounces of pure ethyl alcohol may cause an initial burst of excitement and activity followed by increasing loss of coordination, slurred speech, nausea and drowsiness. This may proceed to stupor, coma and death. Lethal dose of ethyl alcohol ranges from two to five ounces, depending on age and size of the individual.

NOTE: Denatured alcohol contains additives which are extremely poisonous and cannot be removed by normal methods. Ingestion of denatured alcohol will produce much more serious poisoning.

*Prepared by the Bureau of Toxic Substance Assessment, New York State Department of Health. For an explanation of the terms and abbreviations used, see "Toxic Substances: How Toxic is Toxic" available from the New York State Department of Health.

Long Term Exposure:

Prolonged inhalation of concentrations above 5000 ppm may produce symptoms listed under inhalation and the additional symptoms of headache, dizziness, tremors and fatigue. Additives in denatured alcohol may result in other more severe symptoms.

Alcohol has been linked to birth defects and cancer in humans.

EMERGENCY AND FIRST AID INSTRUCTIONS

Inhalation: Move victim to fresh air. Give artificial respiration or oxygen as required.

Skin: Remove soaked clothing. Wash with soap and water for 5 minutes.

Eyes: Wash eyes with water at least 15 minutes. Seek medical attention.

Ingestion: Seek immediate medical attention.

Note to Physician: In a deeply comatose patient, hemodialysis or an infusion of 200 g fructose may be helpful.

FIRE AND EXPLOSION INFORMATION

General: Flammable. Ignites at 55°F (12°C).

Explosive Limits: Upper - 19%, lower - 3.3%.

Extinguisher: Alcohol foam, carbon dioxide, or dry chemical. Water may be ineffective but can be used to cool fire-exposed containers.

REACTIVITY

Conditions to Avoid: Hot environments and open flame.

Materials to Avoid: Reacts violently with perchlorates, peroxides, chromic acid and nitric acid.

PROTECTIVE MEASURES

Storage and Handling: Store in a cool environment, in closed containers, away from flame. Underground or outdoor storage preferred for large quantities.

Engineering Controls: Use in well-ventilated areas.

Protective Clothing (Should not be substituted for proper handling and engineering controls): Chemical goggles, rubber gloves, and boots should be worn.

Protective Equipment: A chemical cartridge respirator appropriate for ethyl alcohol should be worn.

PROCEDURES FOR SPILLS AND LEAKS

Get all workers out of spill area. Put on respirator and other protective clothing. Spread sand or other absorbent material over liquid to absorb it. Shovel into buckets, take to a safe place in the open air. Wash area of spill with soap and water. For final disposal, contact your regional office of the N.Y.S. Department of Environmental Conservation.

For more information:

Contact the Industrial Hygienist or Safety Officer at your worksite or the New York State Department of Health, Bureau of Toxic Substance Assessment, Empire State Plaza, Tower Building, Albany, New York 12237.

Occupational Health Guideline for Isobutyl Alcohol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$
- Synonyms: Isobutanol; IBA; 2-methyl-1-propanol; isopropylcarbinol
- Appearance and odor: Colorless liquid with a mild, non-residual odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for isobutyl alcohol is 100 parts of isobutyl alcohol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 300 milligrams of isobutyl alcohol per cubic meter of air (mg/m^3). The American Conference of Governmental Industrial Hygienists has recommended for isobutyl alcohol a Threshold Limit Value of 50 ppm with a skin notation.

HEALTH HAZARD INFORMATION

• Routes of exposure

Isobutyl alcohol can affect the body if it is swallowed, is inhaled, or comes in contact with the skin or eyes.

• Effects of overexposure

1. **Short-term Exposure:** Overexposure to isobutyl alcohol may cause irritation of the eyes, nose, and throat, headache, dizziness, and drowsiness.
2. **Long-term Exposure:** Drying and cracking of the skin may result from prolonged skin exposure.
3. **Reporting Signs and Symptoms:** A physician should be contacted if anyone develops any signs or symptoms

and suspects that they are caused by exposure to isobutyl alcohol.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to isobutyl alcohol at potentially hazardous levels:

1. **Initial Medical Screening:** Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from isobutyl alcohol exposure.

—Skin disease: Isobutyl alcohol is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although isobutyl alcohol is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although isobutyl alcohol is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of isobutyl alcohol might cause exacerbation of symptoms due to its irritant properties.

2. **Periodic Medical Examination:** Any employee developing the above-listed conditions should be referred for further medical examination.

• Summary of toxicology

Isobutyl alcohol vapor had a narcotic effect in high concentrations (6400 ppm) for mice, and was lethal at 10,000 to 15,000 ppm. In employees, repeated exposures at 100 ppm had no significant effect, although irritation of the eyes and throat were observed in other studies where the vapor concentrations were higher. Isobutyl alcohol is a mild skin irritant. No chronic systemic effects have been reported in humans.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 74
2. Boiling point (760 mm Hg): 108 C (226 F)
3. Specific gravity (water = 1): 0.8
4. Vapor density (air = 1 at boiling point of isobutyl alcohol): 2.6
5. Melting point: -108 C (-162 F)
6. Vapor pressure at 20 C (68 F): 8.8 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 8.7
8. Evaporation rate (butyl acetate = 1): 0.82

• Reactivity

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving isobutyl alcohol.
4. Special precautions: Isobutyl alcohol will attack some forms of plastics, rubber, and coatings. It may react with metallic aluminum at high temperatures.

• Flammability

1. Flash point: 27.8 C (82 F) (closed cup)
2. Autoignition temperature: 427 C (800 F)
3. Flammable limits in air, % by volume (at 212 F): Lower: 1.2; Upper: 10.9
4. Extinguishant: Alcohol foam, dry chemical, carbon dioxide

• Warning properties

1. Odor Threshold: Both Summer and May report an odor threshold of 40 ppm.
2. Eye Irritation Level: Patty states, "Fassett has studied isobutyl alcohol under the same conditions of exposure as for n-butyl alcohol. No evidence of eye irritation was noted with repeated 8-hour exposures to levels on the order of 100 ppm. Animal data showed that it was very similar to n-butyl alcohol in its effects." n-Butyl alcohol is known to be an eye irritant.
3. Evaluation of Warning Properties: Since the odor threshold of isobutyl alcohol is below the permissible exposure limit, it is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

Sampling and analyses may be performed by collection of isobutyl alcohol vapors using an adsorption tube with subsequent desorption with 2-propanol in carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure isobutyl alcohol may be used. An analytical method for isobutyl alcohol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid isobutyl alcohol.

• Clothing wet with liquid isobutyl alcohol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of isobutyl alcohol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the isobutyl alcohol, the person performing the operation should be informed of isobutyl alcohol's hazardous properties.

• Any clothing which becomes wet with liquid isobutyl alcohol should be removed immediately and not reworn until the isobutyl alcohol is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid isobutyl alcohol may contact the eyes.

SANITATION

- Skin that becomes wet with liquid isobutyl alcohol should be promptly washed or showered to remove any isobutyl alcohol.
- Employees who handle liquid isobutyl alcohol should wash their hands thoroughly before eating or smoking.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to isobutyl alcohol may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during spray applications of nitrocellulose lacquers	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation during use of industrial cleaners; during use of paint removers	General dilution ventilation; personal protective equipment
Liberation during hand application of nitrocellulose lacquers; during manufacture of lubricating oil and hydraulic fluids; during manufacture of amino resins and plasticizers	General dilution ventilation
Use during manufacture of nitrocellulose lacquers, paint removers, and industrial cleaners	General dilution ventilation; personal protective equipment
Liberation during manufacture of acetaldehyde; during distillation of whiskey	General dilution ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If isobutyl alcohol gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If isobutyl alcohol gets on the skin, promptly flush the contaminated skin with water. If isobutyl alcohol soaks through the clothing, remove the clothing immediately

and flush the skin with water. If there is skin irritation, get medical attention.

• Breathing

If a person breathes in large amounts of isobutyl alcohol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When isobutyl alcohol has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If isobutyl alcohol is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Isobutyl alcohol should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

- Waste disposal methods:

Isobutyl alcohol may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR ISOBUTYL ALCOHOL

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
8000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 8000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Isopropyl Alcohol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $\text{CH}_3\text{CHOHCH}_3$
- Synonyms: Isopropanol; IPA; 2-propanol; sec-propyl alcohol
- Appearance and odor: Colorless liquid with an odor of rubbing alcohol.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for isopropyl alcohol is 400 parts of isopropyl alcohol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 980 milligrams of isopropyl alcohol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 400 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 800 ppm averaged over a 15-minute period. The NIOSH Criteria Document for Isopropyl Alcohol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Isopropyl alcohol can affect the body if it is swallowed, is inhaled, or comes in contact with the skin or eyes.

• Effects of overexposure

1. **Short-term Exposure:** Exposure to high air concentrations of isopropyl alcohol may cause mild irritation of the eyes, nose, and throat. Drowsiness, headache, and incoordination may also occur. Swallowing isopropyl alcohol may cause drowsiness, unconsciousness, and

death. Gastrointestinal pain, cramps, nausea, vomiting, and diarrhea may also result from swallowing this alcohol.

2. **Long-term Exposure:** Drying and cracking of the skin may result from prolonged skin exposure. Epidemiological investigations have established that a carcinogenic substance is present in isopropyl alcohol manufacturing areas, but have not confirmed isopropyl alcohol as a causative agent of cancer.

3. **Reporting Signs and Symptoms:** A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to isopropyl alcohol.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to isopropyl alcohol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, and respiratory system should be stressed.

—Skin disease: Isopropyl alcohol is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although isopropyl alcohol is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although isopropyl alcohol is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of isopropyl

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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alcohol might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

The most important toxic effect of isopropyl alcohol is narcosis, which occurs in mice at vapor concentrations of 3000 ppm, the effects increasing with the duration of exposure. Exposure to higher concentrations results in ataxia, followed by deep narcosis and death. Reversible changes occurred in the liver fat of mice repeatedly exposed to high concentrations of vapor. Isopropyl alcohol is metabolized fairly rapidly, and acetone may be detected in the urine following heavy exposures. Human volunteers reported mild irritation of the eyes, nose, and throat after 3 to 5 minutes exposure to vapor at 400 ppm; at 800 ppm the results were not severe, but most subjects found the atmosphere to be objectionable. Accidental, extensive wetting of the skin could occur in industrial situations and as isopropyl alcohol is absorbed readily through the skin, the additive effect of inhalation and skin absorption could have serious results. Similarly, there is a risk of deliberate ingestion of isopropyl alcohol as a substitute for ethyl alcohol, which would add to the effects of inhalation. The defatting action of isopropyl alcohol can cause mild skin irritation, but a small percentage of workers may develop contact dermatitis of a more serious nature. No chronic systemic effects have been reported in humans.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 60
2. Boiling point (760 mm Hg): 82 C (180 F)
3. Specific gravity (water = 1): 0.78
4. Vapor density (air = 1 at boiling point of isopropyl alcohol): 2.1
5. Melting point: -89 C (-128 F)
6. Vapor pressure at 20 C (68 F): 33 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): 2.83

• Reactivity

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving isopropyl alcohol.
4. Special precautions: Isopropyl alcohol will attack some forms of plastics, rubber, and coatings. It may also react with metallic aluminum at high temperatures.

• Flammability

1. Flash point: 12 C (53 F) (closed cup)
2. Autoignition temperature: 399 C (750 F)
3. Flammable limits in air, % by volume: Lower: 2.0; Upper: 12.0

4. Extinguishant: Alcohol foam, dry chemical, carbon dioxide

• Warning properties

1. Odor Threshold: Patty reports, "Scherberger et al. stated that the concentration with identifiable odor of isopropyl alcohol is 200 ppm." May reports an odor threshold of 45 ppm.

2. Irritation Level: According to Patty, "mild irritation of the eyes, nose, and throat was induced in human subjects exposed by Nelson and associates for 3 to 5 minutes to 400 ppm of isopropyl alcohol."

3. Evaluation of Warning Properties: Through its odor and irritant effects, isopropyl alcohol can be detected below or at the permissible exposure limit. For the purposes of this guideline, therefore, it is treated as a material with adequate warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• Eight-Hour Exposure Evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of isopropyl alcohol. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of isopropyl alcohol vapors using an adsorption tube with subsequent desorption with 2-butanol in carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure isopropyl alcohol may be used. An analytical method for isopropyl alcohol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental

concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid isopropyl alcohol.
- Any clothing which becomes wet with liquid isopropyl alcohol should be removed immediately and not reworn until the isopropyl alcohol is removed from the clothing.
- Clothing wet with liquid isopropyl alcohol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of isopropyl alcohol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the isopropyl alcohol, the person performing the operation should be informed of isopropyl alcohol's hazardous properties.
- Employees should be provided with and required to use splash-proof safety goggles where liquid isopropyl alcohol may contact the eyes.

SANITATION

- Skin that becomes wet with liquid isopropyl alcohol should be promptly washed or showered to remove any isopropyl alcohol.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to isopropyl alcohol may occur and control methods which may be effective in each case:

Operation

Use as a solvent in spray and heat applications of surface coatings, including stain, varnish, nitrocellulose lacquers, and quick-drying inks and paints

Use as a solvent in application other than spray or heat of surface coatings, including stain, varnish, nitrocellulose lacquers, quick-drying inks and paints, textile coatings and dyes, dopes, and polishes

Use in manufacture and liberation during packing of acetone

Use as a solvent in manufacture of surface coatings and thinners

Use in organic synthesis for isopropyl derivatives, including phenols, acetates, xanthates, ether, amines, myristate, palmitate, nitrite, and glycerin

Use in manufacture of cosmetics, including liniments, skin lotions, permanent wave lotions, and color hair rinses

Liberation during use as a disinfectant and sanitizer; use during cleaning and degreasing operations

Use in preparation, manufacture, and packaging of disinfectants and sanitizers, including rubbing alcohol, other antiseptic solutions, skin astringents, mouth washes, and medicated sprays

Controls

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

Operation

Use in manufacture of cleaning and degreasing agents, including stain and spot removers, glass cleaners, rug and upholstery cleaning, tar remover, liquid soap, and windshield cleaner fluid; use in manufacture of de-icing, de-fogging, and anti-freeze products

Use in extraction and purification of alkaloids, proteins, chlorophyll, perfumes, sulfuric acid, vitamins, kelp, pectin, resins, gums, and waxes

Use in manufacture of rubber products; use as an additive in anti-stalling gasoline, lubricants, denatured ethyl alcohol, hydraulic brake fluids, and rocket fuel

Use in manufacture of adhesives, including nitrocellulose film and microfilm cement; use in manufacture of safety glass

Controls

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

General dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If isopropyl alcohol gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If isopropyl alcohol gets on the skin, flush the contaminated skin with water. If isopropyl alcohol soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

• Breathing

If a person breathes in large amounts of isopropyl alcohol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration.

Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When isopropyl alcohol has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If isopropyl alcohol is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Isopropyl alcohol should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal methods:

Isopropyl alcohol may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR ISOPROPYL ALCOHOL

Condition	Minimum Respiratory Protection* Required Above 400 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style organic vapor canister.
20,000 ppm or less	A gas mask with a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 20,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

The North Carolina Toxic Substances Management Guide

METHANOL

Executive Summary

CAS NUMBER 00067-56-1

Methanol (methyl alcohol) is a colorless, flammable, mobile liquid with a characteristic sharp, sweet/sour odor. Originally obtained by the destructive distillation of wood, it is now usually manufactured from hydrogen and carbon monoxide or carbon dioxide, or by oxidation of hydrocarbons. Annual U.S. production for 1975 was estimated at 2,600,000 tons. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Methanol toxicity is characterized by visual disturbances and metabolic acidosis. Other commonly reported symptoms include dizziness, nausea and vomiting, and headaches. Severe toxicity may develop after inhalation, ingestion or percutaneous exposure. Numerous cases of blindness and death have been reported.

A wide range of variability in toxicity exists among individuals exposed to methanol. General correlations between exposure and effect are therefore difficult to make. Concentrations ranging from 1,200 - 8,300 ppm can lead to impaired vision. Toxicity can be mediated by ethanol which slows the metabolism of methanol to formic acid.

Direct skin contact with methanol has been said to cause dermatitis. Direct contact of methanol with the eyes resulted in chemosis and superficial lesions of the cornea which were rarely of a serious nature.

CARCINOGENICITY. There is no evidence that methanol is carcinogenic in man or animals.

MUTAGENICITY. Methanol is not mutagenic in the Ames' Salmonella typhimurium assay.

TERATOGENICITY AND EMBRYOTOXICITY. There is no evidence to indicate that methanol causes birth defects or is embryotoxic.

CHRONIC. Methanol is slowly eliminated from the body. Often, increased concentrations are found in the blood and tissue after repeated exposures.

Alterations in light sensitivity and variations in EEG patterns have been detected after exposure to low concentrations (0.77 ppm) of methanol. However, chronic occupational exposure to 25 ppm apparently has no harmful effect.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 200 ppm (262 mg/cu m). The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 250 ppm (328 mg/cu m). The importance of skin exposure is noted.

Routes of Human Exposure

OCCUPATIONAL. Methanol is used in the production of formaldehyde and other chemicals

and also as an industrial solvent. Use as a solvent accounts for approximately 90 percent of methanol losses to the environment. Seventy-two occupations that offer exposure to methanol have been reported by the U.S. Department of Labor. A urinary methanol concentration of 10 µg/l measured at the end of the work shift is suggested by one research team as the level above which significant occupational exposure should be expected.

AMBIENT. Methanol has been detected in the municipal drinking water of nine cities, including Durham, North Carolina. It has also been detected in effluents from sewage treatment plants, and latex, paper, and chemical industries, including one chemical company on the upper Catawba River, North Carolina.

An urban air concentration of 13.0 µg/cu m is reported as a "typical value" in samples taken in Pasadena, California.

CONSUMER. Most of the serious cases of methanol poisoning reported during the last 40 years (many of them fatal, while others involved permanent or temporary loss of vision) resulted from the ingestion of methyl alcohol in the belief that it was ethyl alcohol. Death from ingestion of less than 30 ml has been reported.

Environmental Significance

No quantitative data are available on half-life in air or water, nor on bioaccumulation in aquatic organisms. Methanol is reactive with oxidizing material in the atmosphere and is removed by rain. It is highly miscible with water. Sludge digestion is inhibited at 800 mg/l. The aquatic toxicity TLM 96 is more than 1,000 ppm.

Concentrations above 0.15 ppm (0.2 mg/cu m) produced a decrease in photosynthesis in several different tree species.

Data on aquatic plants or algae have not been reported.

North Carolina Production and Users

Production in North Carolina was reported by five companies in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Carodel Corporation, Fayetteville: 50-500 tons/year
E.I. DuPont, Brevard: 500-25,000 tons/year
Hercofina-NC, Wilmington: No report of production figures
New Bern Polyester, New Bern: 500-5,000 tons/year
Wright Chemical, Riegelwood: 500-5,000 tons/year

Users: No information available

Recommended Reviews

Chemical Hazard Information Profiles (CHIPs).
TSCA Chemical Assessment Series, U.S. EPA-500/11-80-011, pages 187-198 (April, 1980).
1979 Annual Report and Scientific Review, Chemical Industry Institute of Toxicology (CIIT), Research Triangle Park, N.C.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

METHANOL

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH METHANOL.

Skin: Wash the contaminated skin with water. Remove clothing immediately if contaminated and wash skin. If irritation persists after washing, get medical attention.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention immediately.

Note to Physician: Gastric lavage with 3-5% sodium bicarbonate. Prompt hemodialysis if blood methanol level is above 50 mg/dl or if there is evidence of acidosis.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors. Isolate for $\frac{1}{2}$ mile in all directions if tank or tankcar is involved in fire.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Burns with a very pale blue flame that is not usually visible in normal light. Fumes may form explosive mixtures in air. Ignites at 12°C (54°F).

EXPLOSIVE LIMITS: Upper - 36.5%, Lower - 6.0%

EXTINGUISHER: Dry chemical or foam; water may not be effective but can be used to cool containers during a fire.

Reactivity

CONDITIONS TO AVOID: Heat, flame

MATERIALS TO AVOID: Strong oxidizers such as chromates, permanganates, hypochlorites and peroxides. Reacts violently with chloroform in strongly caustic solutions (example: with lye or potassium hydroxide). Also reacts strongly with magnesium, bromine and nitric acid.

Protective Measures

HANDLING AND STORAGE: Store in a cool place away from sources of flame and ignition.

ENGINEERING CONTROLS: Provide adequate ventilation; eye wash stations, sinks and showers should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper engineering and handling controls): Wear splash proof goggles, rubber gloves, apron and boots if contact is likely.

PROTECTIVE EQUIPMENT: For levels up to 2,000 ppm use a supplied-air or self-contained breathing apparatus; for levels up to 10,000 ppm use the above with a full facepiece, helmet or hood; for levels up to 25,000 ppm use a supplied-air Type C respirator with full facepiece used in a positive pressure or continuous flow mode.

METHANOL

Profile

Chemical Identification

Alternative Names:

Carbinol	Monohydroxymethane
Colonial Spirit	Pyroxylic Spirit
Coloianian Spirits	Wood Alcohol
Methyl Alcohol	Wood Naphtha
Methyl Hydroxide	Wood Spirit

Chemical Abstract Services (CAS) Registry
Number: 00067-56-1

Registry of Toxic Effects of Chemical Substances
(RTECS) Number: PC 1400000

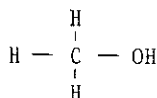
Hazardous Materials Table Identification
Number: UN 1230

RCRA Identification Number: U 154

Molecular Weight: 32.05

Molecular Formula: CH₄O

Structure:



Classification: The simplest of the aliphatic alcohols.

Description: A colorless, flammable liquid with a characteristic sour, sharp, sweet odor.

Uses: Industrial solvent, fuel and in manufacturing of formaldehyde.

Chemical/Physical Data

Boiling point: 64.7°C
Melting point: -97.8°C
Vapor pressure: 100 mm Hg at 21.2°C
Vapor density: 1.11 (Air = 1.0)
Solubility in water: Miscible with water, alcohols, ketones and esters
Specific gravity: 0.8100
Flash point: 12°C closed cup (54°F)
Ignition temperature: 470°C
Explosive limits: 7.3 to 36 percent by volume in air

HUMAN TOXICITY

Methanol is slowly eliminated from the body. Increased concentrations occur in blood and tissue after repeated exposures (ACGIH, 1980).

NIOSH has reviewed the toxic effects of methanol in humans. The information below is taken from the NIOSH Criteria Document (1976).

Methanol toxicity is characterized by visual disturbances and metabolic acidosis. Other commonly reported symptoms include dizziness, nausea and vomiting, and headaches. Severe toxicity may develop after inhalation, ingestion or percutaneous exposure. Numerous cases of blindness and death have been reported.

A wide range of variability in toxicity exists between individuals exposed to methanol. General correlations between exposure and effect are therefore difficult to make. Alterations in light sensitivity and variations in EEG patterns have been detected after exposure to low concentrations (0.77 ppm) of methanol. However, chronic occupational exposure to 25 ppm apparently has no harmful effect. Concentrations ranging from 1,200-8,300 ppm can lead to impaired vision. Toxicity can be mediated by ethanol which slows the metabolism of methanol to formic acid.

Direct skin contact with methyl alcohol has been said to cause dermatitis. Direct contact of methyl alcohol with the eyes resulted in chemosis and superficial lesions of the cornea which were rarely of a serious nature (NIOSH, 1976).

Urinary methanol concentrations reflect levels in blood for exposed subjects. A urinary methanol concentration of 10 µg/l measured at the end of the work shift is suggested by one research team as the level above which significant occupational exposure should be suspected (Ferry et al., 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 2,510 ppm (NIOSH, 1978).

Death from ingestion of less than 30 ml has been reported (TDB, 1981).

Carcinogenicity

No evidence was found to indicate that methanol is carcinogenic in man or animals.

Mutagenicity

Simon, 1977 Methanol was not mutagenic in the Ames' *Salmonella typhimurium* assay. For the test, the bacteria were exposed to methanol vapor in a desiccator.

NIOSH, 1976 Injection of 0.5 percent methanol in grasshoppers produced an incidence of 0.5 percent chromosomal aberration in testicular tissue. This result is considered to be of questionable relevance to human mutagenicity.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that methanol causes birth defects or is embryotoxic.

ANIMAL TOXICITY

Acute Toxicity

Results of lethal studies in several animal species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose
Oral	Rat	13 gm/kg, LD50
	Mouse	0.4 gm/kg, lowest lethal dose
	Rabbit	7.5 gm/kg, lowest lethal dose
	Dog	7.5 gm/kg, lowest lethal dose
	Monkey	7.0 gm/kg, lowest lethal dose
Dermal	Monkey	0.5 gm/kg, lowest lethal dose
Ocular	Rabbit eye	40 mg, moderately toxic
Inhalation	Rat	64,000 ppm/4 hours, lowest lethal concentration

Acute and Chronic Inhalation Data

Results of inhalation studies in animals have been summarized by Treon in a review of methyl alcohol published in Industrial Hygiene and Toxicology, F.A. Patty, Ed. (Treon, 1963). Tabulated effects reproduced from the Treon review are given in the table on the following page.

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

Aquatic toxicity rating: TLM 96 is more than 1,000 (RTECS, 1980).

Verschueren reports a 48-hour TLM for trout as 8,000 ppm and a 24-hour no-effect level for creek chub at 8,000 ppm. Daphnia suffered no effects after 48-hour exposure to 10,000 ppm. The 24-hour TLM for brine shrimp is 10,000 ppm (Verschueren, 1977).

No reports were found on bioaccumulation or biodegradation in aquatic species.

Phytotoxicity

Concentrations above 0.15 ppm (0.2 mg/cu m) produced a decrease in photosynthesis in several different tree species according to the report (U.S. EPA, CHIP, 1980).

No data on aquatic plants or algae were found.

Table 1. Physiological Effects upon Animals of the Inhalation of Methyl Alcohol Concentration

Animal	ppm	mg/liter	exposure, hr	Duration of Signs	Outcome
Cat	132,000	173.0	5-5.5	Narcosis	Died
	65,000	86.0	4.5	Onside	50% died
	33,600	44.0	6	Incoordination	50% died
	18,300	24.0	6	None, but salivation	Survived
Mouse	72,600	95.0	54	Narcosis	Died
	72,600	95.0	28	Narcosis	Died
	54,000	70.7	54	Narcosis	Died
	48,000	62.8	24	Narcosis	Survived
	10,000	13.1	230	Ataxia	Survived
	152,800	200.0	94 min.	Narcosis	
	101,600	133.0	91 min.	Narcosis	
	91,700	120.0	95 min.	Narcosis	Over-all
	76,400	100.0	89 min.	Narcosis	mortality
	61,100	80.0	134 min.	Narcosis	45%
Rat	45,800	60.0	153 min.	Narcosis	
	30,600	40.0	190 min.	Narcosis	
	173,000	227.0			Died
	139,000	182.0		Highest concentration	
				endurable	
	60,000	78.5	2.5	Narcosis, convulsions	
	31,600	41.4	18-20		Died
	22,500	29.5	8	Narcosis	
	13,000	17.0	24	Prostration	
	8,800	11.5	8	Lethargy	
	4,800	6.3	8	None	
	3,000	4.0	8	None	
	50,000	65.4	1	Drowsiness	Survived
	37,000	48.4	8	Prostration, incoordination	
	13,700	17.9	4	None	
Dog	2,000	2.6	24	None	
	10,000	13.1	3 min. 8 times each day at hourly intervals for 100 days	None	Survived
	450-500	0.59-0.65	8 hr/day, 7 days/week for 379 days	None	Survived

Physiological Effects (Continued)

Monkey,	40,000	52.4	4	Illness	Death
rabbit,	40,000	52.4	1 daily		
rat	10,000	13.1	18 daily	for sev- eral weeks	Delayed death
	10,000	13.1	7 daily		Death
	1,000	1.3	41		Delayed death

Table reproduced from Treon, 1963.

ENVIRONMENTAL DATA

Air

An urban concentration of 1.30 µg/cu m is reported as a "typical value" in samples taken in Pasadena, California (Hanst, 1974). No quantitative data are available regarding estimated atmospheric residence time. Methanol is removed by rainfall and is reactive with oxidizing materials in the atmosphere (U.S. EPA, CHIP, 1980). This substance is not photoreactive, and can accumulate to high levels in this medium. A vapor pressure of 1.11 (Air = 1.0) indicates some potential for dispersion in the atmosphere.

Water

Methanol has been detected in the municipal drinking water of nine cities including Durham, North Carolina. It has also been detected in effluents from sewage treatment plants, and latex, paper and chemical industries, including one chemical company on the Upper Catawba River, North Carolina (Shackelford, 1977). Estimated half-life and hydrolysis rate data are not available for this substance. Water is likely to be methanol's primary medium of dispersion because of its miscibility. Evaporation from water can be expected to limit the amount of accumulation in this medium (U.S. EPA, CHIP, 1980). Degradation occurs through reaction with oxidative materials.

Soil

Limited data are available regarding the persistence of methanol in soils. The substance is volatile in this medium, and undergoes biodegradation by soil micro-organisms.

Biota

Methanol acts as a cumulative poison in biota, but can be metabolized to formic acid and formaldehyde (NIOSH, 1976). No quantitative data is available regarding bioaccumulation in aquatic organisms, although some accumulation can be expected with repeated exposure. Similarly, biomagnification is not expected.

Methanol inhibits sludge digestion at 600 mg/l (Verschuere, 1977).

INDUSTRIAL DATA

Production

Production in North Carolina was reported by five companies in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Carodel Corporation, Fayetteville: 50-500 tons/year
E. I. DuPont, Brevard: 5,000-25,000 tons/year
Hercofina-NC, Wilmington: No report of production figures
New Bern Polyester, New Bern: 500-5,000 tons/year
Wright Chemical, Riegelwood: 500-5,000 tons/year
(U.S. EPA, TSCA Inventory, 1980)

Annual U.S. production for 1975 was estimated at 2,600,000 tons. (U.S. EPA, CHIP, 1980)

Consumption and Use

Estimated U.S. Consumption in 1973:

Production of formaldehyde	39 percent
Solvent usage	7.9 percent
Production of dimethyl teraphthalate	6.1 percent
Production of methyl halides	6.1 percent
Production of methylamines	3.3 percent
Production of methyl methacrylate	3.7 percent
Production of acetic acid	3.4 percent
Production of glycol methyl ethers	1.1 percent
Inhibit polymerization of formaldehyde	0.9 percent
Exports	11.6 percent
Miscellaneous	16.9 percent
(U.S. EPA, CHIP, 1980)	

Reported uses of methanol and the corresponding SIC codes are listed below:

Production of formaldehyde, dimethyl terephthalate, methyl halides, methylamines, methyl methacrylate, acetic acid, glycol methyl ethers	2869
Glycol methyl ethers used in jet fuel	2911, 45
Lacquers	2851
Textile dyeing	226
Phthalate production	2869, 2821
Inhibit polymerization of formaldehyde	28
Motor fuel	29
Possible sewage treatment applications	4959
Possible fermentation substrate for animal feed	20
(U.S. EPA, CHIP, 1980)	

Industrial solvent	
Raw material for making formaldehyde and methyl esters	2869
In antifreeze for automotive radiators and air brakes	
As a fuel for picnic stoves	
As a fuel for soldering torches	
As an extractant for animal and vegetable oils	207

Name: Methanol
CAS Number: 00067-56-1

To denature ethanol
Softening agent for pyroxylin plastics
Solvent adjuvant for polymers
Solvent in the manufacture of pharmaceuticals 183
(Chloesterol, streptomycin, vitamins, hormones)
(Merck, 1976)

REGULATORY AND RESEARCH DATA

Existing Guidelines and Standards

Ambient Air

Caution should be exercised in prolonged exposure to elevated concentrations of methanol (Occupational Health Guidelines for Methyl Alcohol (NIOSH/OSHA Sept. 1978)).

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 200 ppm (262 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) for 15 minutes is 250 ppm (328 mg/cu m). The importance of skin exposure is noted.

NIOSH The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 200 ppm (262 mg/cu m) as a time-weighted average and a 15-minute ceiling limit of 800 ppm (1.05 g/cu m).

OSHA The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 200 ppm (262 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. Methanol is classified as a flammable liquid and shipments must carry this label.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Organizations Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1977-1982 Priority Lists of the Chemical Industry Institute of Toxicology (CIIT).

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Occupational Health Guideline for Methylene Chloride

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_2Cl_2
- Synonyms: Dichloromethane; methylene dichloride
- Appearance and odor: Colorless liquid with an odor like chloroform.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for methylene chloride is 500 parts of methylene chloride per million parts of air (ppm) averaged over an eight-hour work shift, with an acceptable ceiling level of 1000 ppm and a maximum peak concentration of 2000 ppm for 5 minutes in any two-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 75 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 500 ppm averaged over a 15-minute period. NIOSH further recommends that permissible levels of methylene chloride be reduced where carbon monoxide is present. The NIOSH Criteria Document for Methylene Chloride should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Methylene chloride can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

• Effects of overexposure

1. *Short-term Exposure:* Methylene chloride is an anesthetic. Inhaling the vapor may cause mental confusion,

light-headedness, nausea, vomiting, and headache. Continued exposure may cause increased light-headedness, staggering, unconsciousness, and death. High vapor concentrations may also cause irritation of the eyes and respiratory tract. Exposure to this chemical may make the symptoms of angina worse. Skin exposure to the liquid may cause irritation. If the liquid is held in contact with the skin, it may cause skin burns. Splashes of the liquid into the eyes may cause irritation.

2. *Long-term Exposure:* Prolonged or repeated exposure to methylene chloride may cause irritation of the skin.

3. *Reporting Signs and Symptoms:* A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to methylene chloride.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to methylene chloride at potentially hazardous levels:

1. *Initial Medical Examination:*

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, cardiovascular system, and blood should be stressed. Clinical impressions of the autonomic nervous system and pulmonary function should be made, with additional tests conducted where indicated.

—Skin disease: Methylene chloride can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver function test: Methylene chloride causes liver damage in animals and this justifies consideration before exposing persons with impaired liver function. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

—Kidney disease: Methylene chloride causes kidney damage in animals and this justifies special considera-

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

tion before exposing persons with impaired renal function.

—Cardiovascular disease: Because of reports of excessive carbon monoxide levels following exposure to methylene chloride, persons with cardiac disease may be at increased risk.

—A complete blood count: A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit. Carboxyhemoglobin values should also be determined periodically, and any level above 5% should prompt an investigation of the worker and his workplace.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

Methylene chloride vapor is a mild narcotic. Exposure of animals to 15,000 ppm for 7 hours was fatal. Animal experiments have shown that continuous exposure to 1,000 ppm can be lethal in 5 to 7 weeks for dogs and that fatty livers, icterus, pneumonia, and splenic atrophy developed in dogs. Cardiac arrhythmias attributed to sensitization of the myocardium have been observed following exposure to high concentrations of some chlorinated hydrocarbons, but dogs exposed to 10,000 and 20,000 ppm of methylene chloride did not show this phenomenon. In human experiments, inhalation of 500 to 1000 ppm for 1 to 2 hours resulted in lightheadedness; there was sustained elevation of carboxyhemoglobin level. High exposures have resulted in deaths in industrial situations. Lower but unknown concentrations have caused such symptoms as lightheadedness, weakness, nausea, and "drunken behavior," resulting in mistakes and accidental falls. Phosgene poisoning has been reported to occur in several cases where methylene chloride was used in the presence of an open fire. Liquid methylene chloride is irritating to the skin on repeated contact. Splashed in the eye, it is painfully irritating, but is not likely to cause serious injury.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 84.9
2. Boiling point (760 mm Hg): 39.8 C (104 F)
3. Specific gravity (water = 1): 1.3
4. Vapor density (air = 1 at boiling point of methylene chloride): 2.9
5. Melting point: -97 C (-142 F)
6. Vapor pressure at 20 C (68 F): 350 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 1.32
8. Evaporation rate (butyl acetate = 1): 27.5

• **Reactivity**

1. Conditions contributing to instability: Heat and moisture
2. Incompatibilities: Contact with strong oxidizers, strong caustics, and chemically active metals such as

aluminum or magnesium powder, sodium and potassium may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving methylene chloride.

4. Special precautions: Liquid methylene chloride will attack some forms of plastics, rubber, and coatings.

• **Flammability**

1. Flash point: None with normal test method
2. Autoignition temperature: 556 C (1033 F)
3. Flammable limits in air, % by volume: (at elevated temperatures) Lower: 12; Upper: 19
4. Extinguishant: Dry chemical, carbon dioxide, foam

• **Warning properties**

1. Odor Threshold: Different authors have reported varying odor thresholds for methylene chloride. Summer and May both report 150 ppm; Kirk-Othmer and Sax both report 25 to 50 ppm; Spector reports 320 ppm. Patty, however, states that since one can become adapted to the odor, it cannot be considered an adequate warning property.

2. Eye Irritation Level: Grant reports that methylene chloride "presents no particular hazard to the eyes." Kirk-Othmer, however, reports that "methylene chloride vapor is seriously damaging to the eyes." Sax agrees with Kirk-Othmer's statement.

The *Documentation of TLV's* states that irritation of the eyes has been observed in workers who had been exposed to concentrations up to 5000 ppm, but that neurasthenic disorders were found in 50% and digestive disturbances in 30% of the persons exposed.

3. Other Information: Gleason reports that methylene chloride may be "irritating to the respiratory tract and may produce pulmonary edema" but gives no quantitative information. The *Documentation of TLV's* reports that in one investigation, irritation of the respiratory passages was observed in workers who had been exposed to concentrations up to 5000 ppm.

4. Evaluation of Warning Properties: Since no detailed information is available relating the irritant effects of methylene chloride to air concentrations and since adaptation to the odor occurs, methylene chloride is treated as a material with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of methylene chloride. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Peak Above Ceiling Evaluation

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of methylene chloride. Each measurement should consist of a 30-minute sample or a series of consecutive samples totalling 30 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure methylene chloride may be used. An analytical method for methylene chloride is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid methylene chloride.

• Non-impervious clothing which becomes wet with liquid methylene chloride should be removed promptly and not reworn until the methylene chloride is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid methylene chloride may contact the eyes.

SANITATION

• Skin that becomes wet with liquid methylene chloride should be promptly washed or showered with soap or mild detergent and water to remove any methylene chloride.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to methylene chloride may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in paint and varnish removers; manufacture of aerosols; cold cleaning and ultrasonic cleaning; and as an extraction solvent for foods and furniture processing	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a cooling solvent in manufacture of cellulose acetate; in organic synthesis; and in plastics processing	Process enclosure; local exhaust ventilation
Use as a solvent in vapor degreasing of thermal switches and thermometers	Process enclosure; local exhaust ventilation
Use as a secondary refrigerant in air conditioning and scientific testing	General dilution ventilation; local exhaust ventilation; personal protective equipment

Operation

Use as an extraction solvent for edible fats, coca, butter, beer flavoring in hops, decaffeinated coffee, oleoresin manufacture, oils, waxes, perfumes, flavorings, and drugs

Use as a solvent for paints, lacquers, varnishes, enamels, adhesives, rubber cements, manufacture of printed circuit boards, as a carrier for pharmaceutical tablet coatings, shrink-fitting of synthetic rubber covers, and dyeing of synthetic fibers

Controls

General dilution ventilation; local exhaust ventilation; personal protective equipment

General dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If methylene chloride gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If methylene chloride gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water if the methylene chloride has not already evaporated. If methylene chloride soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• Breathing

If a person breathes in large amounts of methylene chloride, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When methylene chloride has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND LEAK PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If methylene chloride is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

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RESPIRATORY PROTECTION FOR METHYLENE CHLORIDE

Condition

Minimum Respiratory Protection* Required Above 500 ppm

Vapor Concentration

5000 ppm or less

Any supplied-air respirator with a full facepiece, helmet, or hood.

Any self-contained breathing apparatus with a full facepiece.

Greater than 5000 ppm or
entry and escape from
unknown concentrations

Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

Fire Fighting

Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

Escape

Any gas mask providing protection against organic vapors.

Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

METHYL ETHYL KETONE

Executive Summary

CAS Number: 00078-93-3

Methyl ethyl ketone (MEK) is a colorless, flammable liquid with an acetone-like odor. It is used as an industrial solvent, especially as a coatings solvent. Estimated U.S. production in 1975-76 was 524 million pounds. No federal regulations concerning spills exist at present. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. MEK is readily absorbed by the lungs, gastro-intestinal tract and through the skin. Concentrated short-term exposure may constitute a major hazard to health, with serious residual injury potentially resulting, despite prompt treatment.

CARCINOGENICITY. No carcinogenic effects have been reported for MEK.

MUTAGENICITY. No data on the mutagenicity of MEK in standard tests are available.

TERATOGENICITY AND EMBRYOTOXICITY. Teratogenic and embryotoxic effects have been found after exposure of pregnant rats to MEK.

CHRONIC. MEK is moderately irritating when inhaled or applied to the skin. Symptoms which may occur range from eye, nose and throat irritation (with possible necrosis if inhaled), dermatitis and numbness in the arms to CNS effects.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air of 200 ppm (590 mg/cu m). The recommended Short Term Exposure Limit is 300 ppm (885 mg/cu m). A workroom air concentration of 200 ppm (590 mg/cu m) is both the standard of OSHA and the recommendation standard of NIOSH.

Routes of Human Exposure

OCCUPATIONAL. There is no record of serious human illness from industrial use of MEK.

AMBIENT. No data exist on ambient MEK concentrations.

CONSUMER. The use of MEK as a flavor ingredient is regulated by the Food and Drug Administration. MEK exists in cigarette smoke in concentrations to 500 ppm and in gasoline exhausts in concentrations from below 0.1 ppm to 1.0 ppm.

Environmental Significance

Stable and persistent low levels of MEK may be widely dispersed in water. Removal may be more important than degradation.

Photolytic degradation can be expected of MEK in the atmosphere. MEK is not expected to accumulate or biomagnify in the soil as it can be metabolized by the biota.

Recommended Reviews

Criteria for a Recommended Standard...OCCUPATIONAL EXPOSURE TO KETONES p. 164-166, 181-2. National Institute for Occupational Safety and Health (1978).

Documentation of the Threshold Limit Values, Fourth Edition 1980. American Conference of Governmental Industrial Hygienists, Inc.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

METHYL ETHYL KETONE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Irrigate immediately with large amounts of water occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

Skin: Promptly remove contaminated clothing. Wash with soap and water for at least 5 minutes. Seek medical attention, if necessary.

Inhalation: Move to fresh air. Give artificial respiration or oxygen if necessary. Seek medical attention.

Ingestion: Get medical attention immediately. If medical attention is not immediately available, induce vomiting by touching the back of his throat with his finger or administer syrup of ipecac.

Note to Physician: Induce emesis if greater than 1 mg/kg was ingested. Magnesium or sodium sulfate cathartics should be used after all ingestions.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Restrict entry. Stay upwind; keep out of low areas. Isolate hazard area. Wear self-contained breathing apparatus and full protective clothing. Isolate for $\frac{1}{2}$ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water to reduce vapors.

SMALL SPILLS: Take up with sand or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

MEK will burn if exposed to a source of ignition. Ignites at 474°C.

EXPLOSIVE LIMITS: Upper - 10%, lower - 2%.

SMALL FIRES: Dry chemical, CO₂, water spray or alcohol foam.

LARGE FIRES: Water spray, fog or foam

EMERGENCY ACTION: Move container from fire if it can be done without risk, container may explode in heat of fire. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after the fire is out. For massive fire in cargo area, use unmanned hose holder or monitor nozzles. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank. Flammable vapor may spread away from spill. Runoff to sewer may create fire or explosion hazard.

Reactivity

MATERIALS TO AVOID: Very strong oxidizers present potentially hazardous incompatibilities.

CONDITIONS TO AVOID: Any contact with sources of ignition or extremely high temperatures can cause fire or explosion.

Protective Measures

Preclude from exposure those individuals with diseases of skin, blood or central nervous system. Make annual physical examinations, including blood cell count.

STORAGE AND HANDLING: Close tightly, store in a cool place, and check intermittently for leakage. During shipping, keep in a cool ventilated hold, more than 6 meters apart from the walls of such places with fire and heat as boiler room, kitchen, etc. Do not load together with explosives, oxidizing materials, poisons, organic peroxides and radioactive materials. Preferably provide electrical equipment with spark resistant construction.

ENGINEERING CONTROLS: Adequate ventilation. Shower, sink and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Wear appropriate protective clothing to prevent repeated or prolonged skin contact, including rubber gloves, apron and faceshield or goggles.

PROTECTIVE EQUIPMENT: For levels up to 1000 ppm wear a chemical cartridge respirator with organic vapor cartridges and full facepiece. For levels up to 3000 ppm, wear a gas mask with organic vapor canister, or supplied-air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. For escape, wear a gas mask with organic vapor canister or a self-contained breathing apparatus.

METHYL ETHYL KETONE

Profile

Chemical Identification

Alternative Names:

Acetone, Methyl-
Butanone
2-Butanone
Ketone, Ethyl Methyl
Meetco
MEK
Methyl Acetone

Chemical Abstract Services (CAS) Registry
Number: 00078-93-3

Registry of Toxic Effects of Chemical Substances
(RTECS) Number: EL6475000

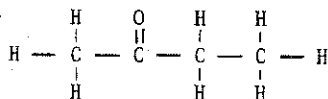
Hazardous Materials Table Identification
Number: UN 1193

RCRA Identification Number: U 159

Molecular Weight: 72.10

Molecular Formula: C_4H_8O

Structure:



Classification: Ketone

Description: Colorless, flammable liquid with acetone-like odor

Use: Industrial solvent

Chemical/Physical Data

Boiling point: 79.6°C at 760 mm Hg
Melting point: -86.4°C
Vapor pressure: 71.2 mm Hg at 20°C
Vapor density: 2.41 (air = 1.0)
Density: 0.805
Solubility in water: 27.5% - decreasing at higher temperatures
Ignition temperature: 474°C
Flash point: (closed cup) 21°F
Explosion level: Upper - 10%; lower - 2%
Odor threshold in air:
absolute perception limit: 2.0 ppm
100% recognition limit: 6.0 ppm

HUMAN TOXICITY

Methyl ethyl ketone (MEK) is classified as a slight local irritant, causing readily reversible changes which disappear after exposure ends. Exposure by inhalation of 100 ppm for 5 minutes produced nasal and throat irritation (NIOSH, 1978). The threshold for eye and nose irritation is approximately 200 ppm for 50% of those unacclimated. Exposure to 200 ppm produce local eye

and nose irritation and if inhaled, can cause necrosis. Dermatitis and numbness in the arms occurred in humans exposed to 300-600 ppm (882-1,760 mg/cu m) (NIOSH, 1978). The lowest toxic concentration is reported as 300 ppm for humans.

MEK is readily absorbed by the lungs, gastrointestinal tract and through the skin. TDB (1982) states that MEK is a major hazard to health during concentrated short-term exposure, with serious residual injury potentially resulting despite prompt treatment. The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 3000 ppm (8,820 mg/cu m) (NIOSH, 1978).

There is no record of serious human illness from industrial use of methyl ethyl ketone (TDB, 1982).

Carcinogenicity

No carcinogenic effects of MEK have been reported.

Mutagenicity

No data are available on the mutagenicity of MEK in standard tests.

Teratogenicity & Embryotoxicity

Evidence of teratogenicity was found when pregnant rats were exposed to methyl ethyl ketone at 1,126 and 2,618 ppm (3,320 and 7,720 mg/cu m) (NIOSE, 1978). There is limited evidence for the embryotoxicity of MEK, however, transplacental migration does occur with accumulation in the fetal blood (TDB, 1982).

ANIMAL TOXICITY

MEK is moderately irritating when inhaled or applied to the skin (TDB, 1982) and can affect the central nervous system (NIOSH, 1978).

Acute Toxicity

Results of lethal studies in two species, as reported in TDB (1982) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	6.86 ml/kg, LD50
Oral	Rat	3400 mg/kg, LD50
Inhalation	Rat	2000 ppm for 4 hours, LCLo
Dermal	Rabbit	1300 mg/kg, LD50

Chronic Toxicity

Results of chronic toxicity studies, as reported in TDB (1982) and RTECS (1982) are listed below:

Route	Species	Dose	Toxic Effect
Inhalation	Rat	1000 ppm (6-15 d preg)	TCLo, teratogenesis
Dermal	Rabbit	500 mg/24 hrs	moderate irritation
	Rabbit	402 mg/24 hrs	mild irritation
	Rabbit	13780 ug/24 hrs.	mild irritation

Aquatic Toxicity

Aquatic toxicity rating: TLM 96 hr is greater than 1000 ppm (TDB, 1982). TLM (24-96) for mosquito fish is 5600 mg/l (Verschuere, 1977).

MEK is easily degraded and is nontoxic to microorganisms at concentrations up to 800 mg/cu m (TDB, 1982).

Inhibition of cell multiplication in *Microcystis aeruginosa* begins at a concentration of 110 mg/l.

ENVIRONMENTAL DATA

Air

MEK can be formed as a degradation product of aldehyde and hydrocarbons in the atmosphere. However, it can be expected to degrade photolytically.

Water

By its chemical analogy to acetone, widespread dispersal of MEK in water is possible. Low levels can be expected to be quite stable and persistent. Removal may be more important than degradation.

Biota

MEK is metabolized by microorganisms and mammals (TDB, 1982). Therefore it is not expected to accumulate or biomagnify.

Soil

There is insufficient data to verify accumulation of MEK. However, the metabolism of MEK by microorganisms in sludge and the volatility of ketones may prevent accumulation of MEK in soil.

Other

MEK is used as a commercial flavor ingredient in non-alcoholic beverages (70 ppm), ice cream (270 ppm), candy (100 ppm) and baked goods (100 ppm) (TDB, 1982).

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production for 1975-76 was 524 million pounds (262,000 tons) (NIOSH, 1978).

Consumption and Use

Estimated U.S. Consumption in 1971:

Vinyl coatings solvent	34 percent
Nitrocellulose coatings solvent	14 percent
Adhesives solvent	13 percent
Acrylic coatings solvent	10 percent
Catalyst initiator in terephthalic acid production	8 percent
Lube oil dewaxing	7 percent
Misc. coatings and applications (TDB, 1982)	14 percent

Reported uses of methyl ethyl ketone and the corresponding SIC codes are listed below:

Manufacture of colorless synthetic resins	2821
Surface coatings solvent (ACGIH, 1980)	252
Solvent for nitrocellulose, adhesives, hardwood pulping	2823, 2981, 2611
In artificial leather manufacture	282
In lacquer and varnish industry	2851
In pharmaceuticals and cosmetics	283
In synthetic rubber	2822, 30

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH	The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 200 ppm (590 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 300 ppm (885 mg/cu m).
NIOSH	The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 200 ppm (590 mg/cu m) as a time-weighted average.
OSHA	The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 200 ppm (590 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. Methyl ethyl ketone is classified as a flammable liquid, and shipments must carry a label which reads "flammable liquid."

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule under the Toxic Substances Control Act.

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International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue. R. J. Lewis and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland (1982).

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Occupational Health Guideline for Tetrachloroethylene*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $\text{CCl}_2 = \text{CCl}_2$
- Synonyms: Perchloroethylene; perchlorethylene; tetrachlorethylene; perk
- Appearance and odor: Colorless liquid with an odor like chloroform or ether.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for tetrachloroethylene is 100 parts of tetrachloroethylene per million parts of air (ppm) averaged over an eight-hour work shift, with a ceiling level of 200 ppm and a maximum acceptable peak of 300 ppm for 5 minutes in any three-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 50 ppm (339 mg/m³) averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 100 ppm (678 mg/m³) averaged over a 15-minute period. The NIOSH Criteria Document for Tetrachloroethylene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Tetrachloroethylene can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

• Effects of overexposure

1. Short-term Exposure: Tetrachloroethylene may cause headache, nausea, drowsiness, dizziness, incoordination, and unconsciousness. It may also cause irritation of

the eyes, nose, and throat and flushing of the face and neck. In addition, it might cause liver damage with such findings as yellow jaundice and dark urine. The liver damage may become evident several weeks after the exposure.

2. Long-term Exposure: Prolonged or repeated overexposure to liquid tetrachloroethylene may cause irritation of the skin. It might also cause damage to the liver and kidneys.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to tetrachloroethylene.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to tetrachloroethylene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the liver and the cardiovascular and neurological systems should be stressed. The skin should be examined for evidence of chronic disorders.

—Liver function tests: Tetrachloroethylene may cause liver damage. A profile of liver function should be obtained by using a medically acceptable array of biochemical tests.

—Urinalysis: Since kidney damage has also been observed from exposure, a urinalysis should be obtained to include at minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

Tetrachloroethylene vapor is a narcotic. Rats did not survive when exposed for longer than 12-18 minutes to 12,000 ppm; when exposed repeatedly to 470 ppm they showed liver and kidney injury. Cardiac arrhythmias

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

attributed to sensitization of the myocardium to epinephrine have been observed with certain other chlorinated hydrocarbons, but exposure of dogs to concentrations of 5000 and 10,000 ppm tetrachloroethylene did not produce this phenomenon. Four human subjects were unable to tolerate 5000 ppm in a chamber for 6 minutes. They experienced vertigo, nausea, and mental confusion during the 10 minutes following cessation of exposure. In an industrial exposure to an average concentration of 275 ppm for 3 hours, followed by 1100 ppm for 30 minutes, a worker lost consciousness; there was apparent clinical recovery 1 hour after exposure but the monitored concentration of tetrachloroethylene in the patient's expired air diminished slowly over a 2-week period. Long-term industrial exposures have been reported to cause various neuropathies, such as numbness, trembling, neuritis, and defects of memory. During the second and third post-exposure weeks, the results of liver function tests became abnormal, suggesting that acute exposure had had a significant effect upon the liver. Other instances of liver injury following industrial exposure have been reported. Other effects on humans of inhalation of various concentrations are as follows: 2000 ppm, mild narcosis within 5 minutes; 600 ppm, sensation of numbness around the mouth, dizziness, and some incoordination after 10 minutes. In human experiments, 7-hour exposures at 100 ppm resulted in mild irritation of the eyes, nose, and throat; flushing of the face and neck; headache; somnolence; and slurred speech. Exposure of the skin to the liquid for 40 minutes resulted in a progressively severe burning sensation beginning within 5 to 10 minutes; the result was marked erythema, which subsided after 1 to 2 hours. The liquid sprayed into rabbits' eyes produced immediate pain and blepharospasm; patches of epithelium were lost, but the eyes recovered completely within 2 days.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
 1. Molecular weight: 165.85
 2. Boiling point (760 mm Hg): 121.2 C (250 F)
 3. Specific gravity (water = 1): 1.62
 4. Vapor density (air = 1 at boiling point of tetrachloroethylene): 5.83
 5. Melting point: -22.4 C (-8 F)
 6. Vapor pressure at 20 C (68 F): 14 mm Hg
 7. Solubility in water, g/100 g water at 20 C (68 F): 0.015
 8. Evaporation rate (butyl acetate = 1): 2.8
- **Reactivity**
 1. Conditions contributing to instability: Heat.
 2. Incompatibilities: Tetrachloroethylene reacts with strong oxidizers and chemically active metals such as barium, lithium, and beryllium.
 3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released when tetrachloroethylene decomposes.

oethylene decomposes.

4. Special precautions: Liquid tetrachloroethylene will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Not combustible

- **Warning properties**

1. Odor Threshold: Both May and Stern state that 50 ppm is the odor threshold for tetrachloroethylene.

2. Eye Irritation Level: Grant reports that "exposure to high concentrations of (tetrachloroethylene) vapor causes mild sensation of irritation to the eyes, but serious injury is not likely." The exact concentrations producing irritation are not mentioned by Grant.

Spector, however, reports that after a 20- to 30-minute exposure to 206 to 235 ppm, eye irritation occurs in humans.

Patty reports "very slight irritation of the eyes" among humans at 106 ppm.

3. Other Information: Spector reports that a 10-minute exposure to 513 to 690 ppm produces nose and throat irritation.

4. Evaluation of Warning Properties: Since the odor threshold of tetrachloroethylene is below the permissible exposure limit, and since eye irritation occurs at a concentration only twice the permissible exposure limit, its warning properties are considered to be adequate.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of tetrachloroethylene. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of tetrachloroethylene. Each measurement should consist of a 30-minute sample or a series of consecutive samples totalling 30 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of

three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure tetrachloroethylene may be used. An analytical method for tetrachloroethylene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid tetrachloroethylene.

- Non-impervious clothing which becomes contaminated with liquid tetrachloroethylene should be removed promptly and not reworn until the tetrachloroethylene is removed from the clothing.

- Clothing wet with liquid tetrachloroethylene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of tetrachloroethylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the tetrachloroethylene, the person performing the operation should be informed of tetrachloroethylene's hazardous properties.

- Employees should be provided with and required to use splash-proof safety goggles where liquid tetrachloroethylene may contact the eyes.

SANITATION

- Skin that becomes contaminated with liquid tetrachloroethylene should be promptly washed or showered with soap or mild detergent and water to remove any tetrachloroethylene.

- Employees who handle liquid tetrachloroethylene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to tetrachloroethylene may occur and control methods which may be effective in each case:

Operation	Controls
Use as dry cleaning solvent; as degreasing and metal cleaning agent; in vapor degreasing of metal parts	Local exhaust ventilation; general dilution; personal protective equipment
Use as chemical intermediate in production of fluorocarbons, pesticides, and trichloroacetic acid	Process enclosure; local exhaust ventilation; general dilution ventilation
Use as scouring, sizing, desizing, solvent and greaser remover in processing and finishing of textiles	Local exhaust ventilation; general dilution; personal protective equipment
Use as general industrial solvent in rubber, textile, printing, soap, and paint remover industries	Local exhaust ventilation; general dilution; personal protective equipment
Use as extraction agent for vegetable and mineral oils and in pharmaceutical industry; as vermifuge; as laundry treatment for presoaking and as drying medium in metal and wood industries	Local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

Eye Exposure

If tetrachloroethylene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If tetrachloroethylene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If tetrachloroethylene soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• Breathing

If a person breathes in large amounts of tetrachloroethylene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When tetrachloroethylene has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If tetrachloroethylene is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.

2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

- Waste disposal method:

Tetrachloroethylene may be disposed of by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

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* SPECIAL NOTE

Tetrachloroethylene appears on the OSHA "Candidate List" of chemicals being considered for further scientific review regarding its carcinogenicity (*Federal Register*, Vol. 45, No. 157, pp. 5372-5379, 12 August 1980). The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 20, 1979.

RESPIRATORY PROTECTION FOR TETRACHLOROETHYLENE

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
500 ppm or less	Any chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 500 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Toluene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_5CH_3$
- Synonyms: Toluol; phenylmethane; methylbenzene
- Appearance and odor: Colorless liquid with an aromatic odor, like benzene.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for toluene is 200 parts of toluene per million parts of air (ppm) averaged over an eight-hour work shift, and during any such work shift, 300 ppm toluene may not be exceeded except that a peak of 500 ppm toluene is permitted for 10 minutes during the eight-hour work shift. NIOSH has recommended that the permissible exposure limit be reduced to 100 ppm toluene averaged over an eight-hour work shift with a ceiling level of 200 ppm averaged over a ten-minute period. The NIOSH Criteria Document for Toluene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Toluene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

• Effects of overexposure

1. Short-term Exposure: Toluene may cause irritation of the eyes, respiratory tract, and skin. It may also cause fatigue, weakness, confusion, headache, dizziness, and drowsiness. Peculiar skin sensation may be produced

such as a "pins and needles feeling" or numbness. Very high concentrations may cause unconsciousness and death. The liquid splashed in the eye may cause irritation and temporary damage. Inhalation may also cause difficulty in seeing in bright light. If liquid toluene is splashed in the eyes, it will cause temporary irritation.

2. Long-term Exposure: Repeated or prolonged exposure to liquid toluene may cause drying and cracking of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to toluene.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to toluene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, liver and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Since proper kidney function is necessary for biologic monitoring, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. The urine should be analyzed for hippuric acid to obtain a background level.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. Hippuric acid level in urine may be an indicator of the level of toluene exposure.

• Summary of toxicology

Toluene vapor causes narcosis. Controlled exposure of human subjects to 200 ppm for 8 hours produced mild fatigue, weakness, confusion, lacrimation, and paresthesia; at 600 ppm for 8 hours there were also euphoria, headache, dizziness, dilated pupils and nausea; at 800

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

ppm for 8 hours, symptoms were more pronounced, and after-effects included nervousness, muscular fatigue, and insomnia persisting for several days. Severe but reversible liver and kidney injury occurred in a person who was a glue-sniffer for 3 years; the chief component of the inhaled solvent was toluene (80% V/V); other ingredients were not listed. In workers exposed for many years to concentrations in the range of 80 to 300 ppm, there was no clinical or laboratory evidence of altered liver function. Toluene exposure does not result in the hematopoietic effects caused by benzene; the myelotoxic effects previously attributed to toluene are judged by more recent investigations to be the result of concurrent exposure to benzene present as a contaminant in the commercial toluene used. Most of the toluene absorbed from inhalation is metabolized to benzoic acid, conjugated with glycine in the liver to form hippuric acid, and excreted in the urine; the average amount of hippuric acid excreted in the urine by individuals not exposed to toluene is approximately 0.7 to 1.0 g/l of urine. The liquid splashed in the eyes of two workers caused transient corneal damage and conjunctival irritation; complete recovery occurred within 48 hours. Repeated or prolonged skin contact with liquid toluene has a defatting action, causing drying, fissuring, and dermatitis.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 92.1
2. Boiling point (760 mm Hg): 111 C (231 F)
3. Specific gravity (water = 1): 0.86
4. Vapor density (air = 1 at boiling point of toluene): 3.14
5. Melting point: -95 C (-139 F)
6. Vapor pressure at 20 C (68 F): 22 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.05
8. Evaporation rate (butyl acetate = 1): 2.24

• Reactivity

1. Conditions contributing to instability: Containers may burst at elevated temperatures.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon dioxide and carbon monoxide) may be released in a fire involving toluene.
4. Special precautions: Toluene will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Flash point: 4 C (40 F) (closed cup)
2. Autoignition temperature: 480 C (896 F)
3. Flammable limits in air, % by volume: Lower: 1.27; Upper: 7.1
4. Extinguishant: Carbon dioxide, dry chemical, foam

• Warning properties

1. Odor Threshold: The American National Stand-

ards Institute (ANSI) states that "the odor of toluene is detectable by most people at concentrations in the range of 10 to 15 ppm. The odor has little value as a warning property."

Patty points out that olfactory fatigue occurs rapidly upon exposure to toluene.

2. Eye Irritation Level: Grant states that "the vapors of toluene cause noticeable sensation of irritation to human eyes at 300 to 400 ppm in air, but even at 800 ppm irritation is slight."

ANSI reports that "irritation of eyes, mucous membranes, and upper respiratory tract may occur while workers are exposed to low concentrations of toluene. There is a considerable range of variation (100 to 500 ppm) between individuals, some finding any concentration of toluene objectionable. Commercial grades of toluene vary in irritant properties."

3. Evaluation of Warning Properties: Because of its irritant effects, toluene is judged to have good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• Eight-Hour Exposure Evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of toluene. Each measurement should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Peak Above Ceiling Evaluation

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of toluene. Each measurement should consist of a 10-minute sample or a series of consecutive samples totalling 10 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with a subsequent desorption of toluene with carbon disulfide and gas

chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure toluene may be used. An analytical method for toluene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

Methods for Set V" (order number PB 262 524).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid toluene.

- Any clothing which becomes wet with liquid toluene should be removed immediately and not worn until the toluene is removed from the clothing.

- Clothing wet with toluene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of toluene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the toluene, the person performing the operation should be informed of toluene's hazardous properties.

- Employees should be provided with and required to use splash-proof safety goggles where liquid toluene may contact the eyes.

- Where there is any possibility that employees' eyes may be exposed to toluene, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes wet with liquid toluene should be promptly washed or showered with soap or mild detergent and water to remove any toluene.

- Employees who handle liquid toluene should wash their hands thoroughly with soap or mild detergent and water before eating or smoking.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to toluene may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in pharmaceutical, chemical, rubber, and plastics industries; as a thinner for paints, lacquer, coatings, and dyes; as a paint remover; insecticides	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as starting material and intermediate in organic chemical and chemical synthesis industries	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use in manufacture of artificial leather; fabric and paper coatings; photogravure ink production; spray surface coating; as a diluent (cellulose ester lacquers)	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as constituent in formulation of automotive and aviation fuels	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If liquid toluene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If liquid toluene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and

water. If liquid toluene soaks through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of toluene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When toluene has been swallowed, get medical attention immediately. Do not attempt to make the exposed person vomit.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If toluene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber. Toluene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of toluene vapors are permitted.

- **Waste disposal method:**

Toluene may be disposed of by atomizing in a suitable combustion chamber.

ADDITIONAL INFORMATION

To find additional information on toluene, look up toluene in the following documents:

- Medical Surveillance for Chemical Hazards
- Respiratory Protection for Chemical Hazards
- Personal Protection and Sanitation for Chemical Hazards
- NIOSH Criteria Document for Toluene (July 1973)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

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RESPIRATORY PROTECTION FOR TOLUENE

Condition	Minimum Respiratory Protection* Required Above 200 ppm
Vapor Concentration	
500 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s). Any supplied-air respirator. Any self-contained breathing apparatus.
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
2000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 2000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

TRICHLOROETHANES

Executive Summary

CAS NUMBER: 00071-55-6

1,1,1-Trichloroethane CAS NUMBER 00079-00-5

1,1,2-Trichloroethane CAS NUMBER 25323-89-1

Mixed isomers

The trichloroethanes are colorless, nonflammable liquids used as solvents, chemical intermediates, and components of adhesives, lacquers, and other products. Estimated U.S. production of 1,1,1-trichloroethane in 1976 was 316,000 tons. 1,1,2-trichloroethane is produced in smaller volumes, an estimated 2,000 tons in 1978. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. 1,1,1-Trichloroethane is an anesthetic and is capable of causing death when inhaled at concentrations in excess of 14,000-15,000 ppm. Hepatic effects include liver function abnormalities and cellular damage. Cardiovascular effects are reported, including drop in blood pressure, decreased heart rate, cardiac arrhythmias, and blood clotting changes. Skin contact causes redness and scaling but the skin is not believed to be a significant exposure route.

1,1,2-Trichloroethane, on the other hand, is reported to be readily absorbed through the skin. Its toxicological properties are believed to resemble those of symmetric tetrachloroethane and chloroform. Concentrations on the order of 13,600 ppm produce deep narcosis and death during a two-hour exposure. Narcotic concentrations result in irritation of the eyes and nose.

CARCINOGENICITY. There is limited evidence that 1,1,2-trichloroethane is carcinogenic in mice. NIOSH recommends that it would be prudent to handle the compound in the workplace as if it were a human carcinogen. The available data are insufficient to permit an evaluation of the carcinogenicity of 1,1,1-trichloroethane.

MUTAGENICITY. 1,1,1-Trichloroethane was found to be mutagenic in *Salmonella typhimurium* but 1,1,2-trichloroethane was not.

TERATOGENICITY & EMBRYOTOCICITY. 1,1,1-Trichloroethane did not produce teratogenic effects in rats or mice exposed 7 hours per day to 875 ppm during the period of organogenesis.

CHRONIC. In diabetic individuals, trichloroethanes may cause a significant increase in SGPT activity (17-fold increase in diabetic rats).

1,1,2-trichloroethane is readily absorbed through the intact skin.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect: 350 ppm (1.9 mg/cu m) for the 1,1,1-isomer, and 10 ppm (0.045 gm/cu m) for the 1,1,2-isomer. The Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period up to 15 minutes) is 450 ppm (2.5 gm/cu m) for the 1,1,1-isomer, and 20 ppm (0.09 gm/cu m) for the 1,1,2-isomer.

Routes of Human Exposure

OCCUPATIONAL. In 1974, the uses of 1,1,1-trichloroethane in the U.S. were the following: cold cleaning of metals, 37 percent; vapor degreasing, 34 percent; chemical intermediate for vinylidene chloride, 23 percent; and other applications, 6 percent.

The National Occupational Health Survey (1974) indicated that workers primarily exposed to 1,1,2-trichloroethane were those in the blast furnace and steel mill, telephone communication, engineering and scientific instrument manufacturing industries.

AMBIENT. Rural air concentrations of 1,1,1-trichloroethane have been reported ranging up to 0.45 ppb (2.5 mg/cu m). Urban levels as high as 14 ppb (76 mg/cu m) have been observed during an inversion. The 1,1,1-isomer has been identified in air samples from many locations (data were not reported for the 1,1,2-isomer).

Both 1,1,1- and 1,1,2-trichloroethane have been detected in raw water and finished drinking water at levels ranging from 0.1 - 8.5 mg/l. 1,1,1-Trichloroethane was detected in drinking water samples from Durham, North Carolina, but no concentrations were reported.

The 1,1,1-isomer has been detected in soil and sediment samples taken near trichloroethylene plants at levels as high as 100 ppb (100 ug/kg). Several marine organisms have been found to have small concentrations of the same isomer (usually reported together with carbon tetrachloride). Neither isomer is known to occur as a natural product.

CONSUMER. 1,1,1-Trichloroethane has been detected in many food products including meat, oils, fats, tea, fruits, and vegetables at levels ranging from 1-10 mg/kg. It is used in aerosol and other consumer products, such as insecticides and spot cleaners.

Both 1,1,1- and 1,1,2-trichloroethane were approved by the U.S. Food and Drug Administration as constituents of adhesives used as components of food packaging or containers.

Environmental Significance

Estimated atmospheric residence time is reported as 970 days for 1,1,1-trichloroethane and 3 years as an upper limit for 1,1,2-trichloroethane. Estimated half-life in water is 17-20 minutes for the 1,1,1-isomer and 21 minutes for the 1,1,2-isomer.

Freshwater data indicate that acute toxicity occurs at concentrations as low as 18 g/l for the two trichloroethanes; chronic toxicity occurs at concentrations as low as 9.4 g/l. Acute toxicity to saltwater fish and invertebrate species occurs at concentrations as low as 31.2 g/l for 1,1,1-trichloroethane.

A concentration factor of 9 was observed for the 1,1,1-isomer in the bluegill, and a concentration factor of 11.5 was calculated for the 1,1,1-isomer based on the octanol/water partition coefficient.

Toxicity to algae was observed for 1,1,2-trichloroethane at concentrations as low as 443 mg/l. The aquatic toxicity rating is 10-100 (TLm 96) for both isomers.

Recommended Reviews

Chemical Hazard Information Profile, U.S. Environmental Protection Agency, EPA-560/11-80-011 (1980).

Ambient Water Quality Criteria for Chlorinated Ethanes, U.S. Environmental Protection Agency, EPA/440-5-80-029 (1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

TRICHLOROETHANES

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

- Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING TRICHLOROETHANE.
- Skin: Wash the contaminated skin promptly with soap or mild detergent and water. Remove clothing if contaminated and wash skin.
- Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
- Ingestion: Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover, move containers, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Non-flammable

Reactivity

MATERIALS TO AVOID: Reacts violently with acetone, nitrites, oxygen, sodium and sodium hydroxide. Corrosive to aluminum.

CONDITIONS TO AVOID: Hot metals or ultraviolet radiation will decompose 1,1,2-trichloroethane to form irritating and poisonous gases.

Protective Measures

HANDLING AND STORAGE: Store in a cool, dark, dry place. Do not store in aluminum containers.

ENGINEERING CONTROLS: Provide adequate ventilation. Sinks, showers and eyewash stations should be readily available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Gloves and apron of polyvinyl alcohol, neoprene (Do not use natural rubber) or leather, and splash proof goggles should be worn if contact with trichloroethane is likely.

PROTECTIVE EQUIPMENT: For exposure up to 500 ppm use a supplied-air, or self-contained breathing apparatus with face shield. For escape from a contaminated area use a gas mask with organic vapor canister, or self-contained breathing apparatus.

TRICHLOROETHANES

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Aerothene II
Chloroethene
Chloroform, Methyl-
Chlorten
Ethane, 1,1,1-trichloro-
Methyl chloroform
Solvent 111
Alpha-trichloroethane

Chemical Abstract Services (CAS) Registry
Number: 00071-55-6

Registry of Toxic Effects of Chemical Substances
(RTECS) Number: KJ 2975000

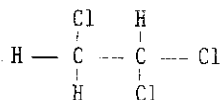
Hazardous Materials Table Identification
Number: UN 2831

RCRA Identification Number: U 226

Molecular Weight: 133.42

Molecular Formula: $C_2H_3Cl_3$

Structure:



Classification: Chlorinated aliphatic hydrocarbon

Description: A colorless, nonflammable liquid

Uses: As a solvent and chemical intermediate

Chemical/Physical Data

Boiling point: 74.1°C
Melting point: -32.6°C
Vapor pressure: 100 mm Hg at 20°C; 155 mm at 30°C
Vapor density: 4.63 (Air = 1.0)
Solubility in water: 4,400 mg/l at 20°C
Specific gravity: 1.34

Name: 1,1,2-Trichloroethane

Alternative Names:

Ethane trichloride
Beta-1
Beta-trichloroethane
1,1,2-Trichloroethane
Vinyltrichloride

Chemical Abstract Services (CAS) Registry
Number: 00079-00-5

Registry of Toxic Effects of Chemical Substances
(RTECS) Number: KJ 3150000

Hazardous Materials Table Identification
Number: Not listed.

RCRA Identification Number: U 226

Molecular Weight: 133.42

Molecular Formula: $C_2H_3Cl_3$

Structure:

$$\begin{array}{c} \text{H} \quad \text{Cl} \\ | \quad | \\ \text{H} \quad \text{C} \quad \text{C} \quad \text{Cl} \\ | \quad | \\ \text{H} \quad \text{Cl} \end{array}$$

Classification: Chlorinated aliphatic hydrocarbon

Description: A colorless, nonflammable liquid with a pleasant odor

Uses: As a solvent and chemical intermediate

Chemical/Physical Data

Boiling point: 113.8°C
Melting point: -36.5°C
Vapor pressure: 19 mm Hg at 20°C; 32 mm at 30°C; 40 mm at 35°C
Vapor density: 4 (Air = 1.0)
Solubility in water: 4,500 mg/l at 20°C
Specific gravity: 1.44

HUMAN TOXICITY

1,1,1-Trichloroethane may affect a variety of human organs or systems including hematologic, cardiovascular, gastrointestinal, hepatic biliary, neurologic, dermatologic, ophthalmologic, and others. Specific adverse neurological effects include central nervous system depression, incoordination, inebriation, headache, dizziness, unconsciousness, generalized weakness, sleepiness, mental confusion and other effects. Hepatic effects include liver function abnormalities and cellular damage. Cardiovascular effects such as drop in blood pressure, decrease in heart rate, and cardiac arrhythmias are reported. Blood clotting changes are also noted (NIOSH, 1978).

Adverse human effects of the 1,1,2-isomer are not reported (NIOSH, 1978).

While comparatively low in systemic toxicity, 1,1,1-trichloroethane is an anesthetic and is capable of causing death when inhaled at concentrations in excess of 14,000-15,000 ppm. Beginning anesthetic effects occur at concentrations approaching 500 ppm. It is reported that "repetitive vapor exposure to 1,1,1-trichloroethane produced an untoward subjective or objective health response..." (ACGIH, 1986).

Skin contact with the 1,1,1-isomer causes redness and scaling. Although absorption through the skin can occur, this is not believed to be a significant exposure route (ACGIH, 1980). The 1,1,2-isomer is reported to be readily absorbed through the skin (U.S. EPA, CHIP, 1980).

The 1,1,2-isomer is believed to resemble symmetric tetrachloroethane and chloroform in its toxicological properties (ACGIH, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 500 ppm for 1,1,2-trichloroethane (NIOSH/OSHA, 1978).

Carcinogenicity

- U.S. EPA, WQC 1980 The U.S. EPA Carcinogen Assessment Group (CAG) has determined 1,1,2-trichloroethane is carcinogenic in animals and therefore poses a risk to man. Water Quality Criteria for the 1,1,2-isomer are based on incremental increase of cancer with increasing exposures, assuming nonthreshold behavior.
- IARC, 1979 The available data do not permit an evaluation of the carcinogenicity of 1,1,1-trichloroethane to be made. There is limited evidence that 1,1,2-trichloroethane is carcinogenic in mice.
- NIOSH, 1978 NIOSH recommends that it would be prudent to handle 1,1,2-trichloroethane in the workplace as if it were a human carcinogen. This recommendation is based primarily on National Cancer Institute (NCI) data indicating that laboratory animals administered the compound experienced a statistically significant excess of cancer as compared to control animals.
- OSHA, 1980 1,1,2-Trichloroethane was found to be carcinogenic in male and female mice at two dose levels (390 and 190 mg/kg-day, 5 days/week for up to 78 weeks).

Mutagenicity

- IARC, 1979 1,1,1-Trichloroethane is mutagenic in *Salmonella typhimurium*; but 1,1,2-trichloroethane was not.

Teratogenicity & Embryotoxicity

1,1,1-Trichloroethane did not produce teratogenic effects in rats or mice exposed 7 hours per day to 875 ppm during the period of organogenesis (ACGIH, 1980).

ANIMAL TOXICITY

All of the chloroethane compounds are known to cause central nervous system depression, usually expressed as abnormal weakness, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsciousness. Chloroethanes are irritating to the eyes and skin (NIOSH, 1978).

The 1,1,1-isomer has been studied extensively in several species. Less data are available for the 1,1,2-isomer. Reported effects differ for the two isomers.

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
1,1,1- Oral	Rat	10.3 gm/kg, LD50
	Mouse	11.2 gm/kg, LD50
	Dog	.75 gm/kg, LD50
	Rabbit	5.6 gm/kg, LD50
	Guinea pig	9.4 gm/kg, LD50
1,1,2- Oral	Rat	1.1 gm/kg, LD50
	Dog	.5 gm/kg, Lowest lethal dose
1,1,1- Inhalation	Rat	1,000 ppm (5.4 gm/cu m) for 24 hours, lowest LC
1,1,2- Oral	Rat	500 ppm (2.7 gm/cu m) for 8 hours, lowest LC
	Cat	2,426 ppm (13 gm/cu m) for 4.5 hours, lowest LC

Chronic Toxicity

Liver and kidney injury have resulted in dogs and guinea pigs exposed to 1,1,2-trichloroethane (NIOSH, 1978).

Aquatic Toxicity

Aquatic toxicity rating: TLM 96 is 10-100 ppm for both 1,1,1- and 1,1,2-trichloroethane (RTECS, 1980).

The U.S. Water Quality Criteria for the protection of aquatic life are given below:

The available freshwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity occurs at concentrations as low as 18 mg/l for 1,1,1-trichloroethanes. Chronic toxicity occurs at concentrations as low as 9.4 mg/l for 1,1,2-

trichloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

The available saltwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity to fish and invertebrate species occurs at concentrations as low as 31 mg/l for 1,1,1-trichloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Bioaccumulation: A concentration factor of 9 was observed for the 1,1,1-isomer in the bluegill exposed, and a concentration factor of 11.5 was calculated for the 1,1,2-isomer based on the octanol/water partition coefficient (U.S. EPA, WQC, 1980).

Biodegradation in aquatic species: No data are available.

Phytotoxicity

Toxicity to algae was observed for 1,1,1-trichloroethane at concentrations as low as 443 mg/l (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

Rural levels of 1,1,1-trichloroethane have been reported ranging from below the detection limit to 0.45 ppb (2.5 ug/cu m). Urban levels as high as 14 ppm (76 ug/cu m) have been observed during an inversion (Lillian, 1975; Lillian, 1976; U.S. EPA, ETS, 1977). The 1,1,1-isomer has been identified in air samples from many locations, data are not reported for the 1,1,2-isomer (IARC, 1979).

The 1,1,2-isomer has an estimated atmospheric residence time of 3 years (as an upper limit) (Callahan, 1979). The 1,1,1-isomer has an estimated atmospheric residence time of 970 days (Cupitt, 1980) and an estimated oxidative half-life in air of 1.1 - 8 years (Callahan, 1979). The high volatility of these substances results in substantial atmospheric loading, but degradation is rapid. Release rates and accumulation are lower than for other chlorinated compounds such as tetrachloroethylene.

Water

Both 1,1,1- and 1,1,2-trichloroethane have been detected in raw water and municipal drinking water at levels ranging from 0.1 - 8.5 ug/l (IARC, 1979). 1,1,1-Trichloroethane was detected in drinking water samples from Durham, North Carolina but no concentrations were reported (Shackelford, 1977).

The 1,1,1-isomer has an estimated half-life in water of 17-23 minutes (Verschuieren, 1977) based on evaporation, and degrades via hydrolysis (experimental half-life of 6 months; Callahan, 1979). The 1,1,2-isomer has similar properties. Although somewhat resistant to hydrolysis and oxidation, rapid volatilization to the atmosphere is expected. Low levels may be quite stable and widely dispersed in this medium.

Soil

Limited data suggest some preferential adsorption onto organic sediments (Callahan, 1979). Volatilization is probably more important as a removal process than degradation. Some accumulation can be expected.

Biota

There is no evidence to suggest significant bioaccumulation in this medium. There is some evidence for resistance to microbial degradation (Callahan, 1979 and U.S. EPA, WQC, 1980), but no magnification is expected.

1,1,1-Trichloroethane has been detected in many food products, including meat, oils, fats, tea, fruits, and vegetables at levels ranging from 1010 ug/kg (IARC, 1979). It has also been detected in soil and sediment samples taken near trichloroethylene plants at levels as high as 100 ppb (199 ug/kg) (U.S. EPA, OTS, 1977). Several marine organisms have been found to have small concentrations of the 1,1,1-isomer (usually reported together with carbon tetrachloride). Neither isomer is known to occur as a natural product (IARC, 1979).

INDUSTRIAL DATA

Production

No production in North Carolina was reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production for the 1,1,1-isomer in 1976 was 316,000 tons (IARC, 1979). The estimated U.S. production for the 1,1,2-isomer in 1978 was 2,000 tons (U.S. EPA, CHIP, 1980).

Consumption and Use

Quantitative consumption pattern data are available for 1,1,1-trichloroethane only. These data are given below:

Cold cleaning of metal	37 percent
Vapor degreasing	34 percent
Chemical intermediate for vinylidene chloride	23 percent
Miscellaneous (IARC, 1979)	6 percent

Reported uses of trichloroethanes and their corresponding SIC codes are listed below:

1,1,1-Trichloroethane

Cold cleaning solvent for electric motors, generators, electronic apparatus	35
High purity cleaning of missile parts, semiconductors, and high vacuum equipment	376, 3674, 36
Vapor degreasing	-
In adhesives and as a resin solvent	2891, 282
Lubricant carrier	-
Coolant for drilling and tapping stainless steel	34
Solvent for drain cleaners, shoe polishes, spot remover, insecticides, and printing inks (IARC, 1979)	2869, 721, 2879, 2893

1,1,2-Trichloroethane

Chemical intermediate for production of vinylidene chloride (use reportedly terminated in 1978)	2869
Solvent for fats, waxes, and natural resins	28
Production of Teflon tubing	282
In adhesives, lacquers, and coating formulations (U.S. EPA, CHIP, 1980)	2891, 285
Manufacture of 1,1,-dichloroethane (U.S. EPA, WQC, 1980)	2869

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 350 ppm (1.9 gm/cu m) as a time-weighted average for 1,1,1-trichloroethane. The recommended Short Term Exposure Limit (STEL) for the 1,1,1-isomer is 450 ppm (2.5 gm/cu m). The time-weighted average for the 1,1,2-isomer is 10 ppm (0.45 gm/cu m) and the STEL is 20 ppm (0.9 gm/cu m).

NIOSH The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 350 ppm (1.9 gm/cu m) as a ceiling limit for 1,1,1-trichloroethane. NIOSH has recommended the

handling of 1,1,2-trichloroethane as if it were a human carcinogen. Exposure should be limited to as few employees as possible while minimizing workplace exposure levels with engineering and work practice controls.

OSHA The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 350 ppm (1.9 gm/cu m) for 1,1,1-trichloroethane and 10 ppm for 1,1,2-trichloroethane as a time-weighted average.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject of a Risk Assessment (1,1,2-trichloroethane) prepared by U.S. EPA's Carcinogen Assessment Group (CAG) for the Office of Water Planning and Standards.

Appears on the Priority List of the Interagency Testing Committee.

Subject to a proposed rule by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act, Section 4(a) that would require manufacturers and processors to test the chemical according to standards EPA had adopted. Proposed testing includes: structural teratogenicity; aquatic vertebrates--acute and chronic toxicity; aquatic invertebrates--chronic toxicity; birds--chronic toxicity; terrestrial plants--early seedling growth; seed germination; root elongation; bioconcentration--plant uptake/translocation; and soil absorption (U.S. EPA, Federal Register, Vol. 46, No. 108, June 5, 1981).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity of 1,1,1-trichloroethane. Testing of rats and mice by gavage is in testing phase (FY 1980) (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

Approved (both isomers) by the U.S. Food and Drug Administration as a constituent of adhesives used as component of articles intended for use in packaging, transporting, or holding food.

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TRICHLOROETHYLENE

The information in this sheet applies to workplace exposure resulting from processing, manufacturing, storing or handling and is not designed for the population at large. Any generalization beyond occupational exposures should not be made. The best industrial hygiene practice is to maintain concentrations of all chemicals at levels as low as is practical.

Chemical Names: Trichloroethylene, trichloroethene, ethylene trichloride; CAS 79-01-6.

Trade Names: Algylen, Benzinol, Chlorilen, Fleck-flip, Triclene, Tric, TCE and others.

Uses: The liquid is used as a degreaser and as a solvent in dry cleaning operations.

PHYSICAL INFORMATION

Appearance: Clear, colorless liquid.

Odor: Strong, sweet.

Minimum Detectable by Odor: 25 ppm.

Evaporation: Liquid evaporates slowly.

Behavior in Water: Does not mix, sinks.

HEALTH HAZARD INFORMATION

OSHA Standard: Average 8 hour exposure limit -- 100 ppm.

NIOSH Recommended Limit: Average 10 hour day/40 hour week -- 100 ppm.

ACGIH Recommended Limit: Average 8 hour exposure limit -- 50 ppm.

Short Term Exposure:

Inhalation: Headache, sleepiness, nausea, vomiting, dizziness and coughing have been felt around 100 ppm. Unconsciousness can result at 3,000 ppm. Exposure to 8,000 ppm can cause death.

Skin: Can be absorbed through skin. May cause irritation, burning or redness.

Eyes: May cause irritation, burning or watering.

Ingestion: Can cause drunkenness, vomiting, diarrhea or abdominal pain. Unconsciousness, liver or kidney damage, vision distortion and death have been reported at large doses.

Long Term Exposure:

Contact with vapor levels near 100 ppm can cause giddiness, nervous exhaustion, increased sensitivity to alcohol including redness in the face (trichloroethylene blush), the ability to become addicted to the vapor, as well as effects of acute exposure listed above. Higher levels can alter one's heart rate. Repeated contact with hands can cause excessive dryness, cracking, burning, loss of sense of touch or temporary paralysis of fingers. Most of these effects seem to go away after exposure has stopped.

Trichloroethylene is considered a cancer suspect agent because high levels cause liver cancer in mice. Whether it causes cancer in humans is unknown.

*Prepared by the Bureau of Toxic Substance Assessment, New York State Department of Health. For an explanation of the terms and abbreviations used, see "Toxic Substances: How Toxic is Toxic" available from the New York State Department of Health.

EMERGENCY AND FIRST AID INSTRUCTIONS

Inhalation: Get victim to fresh air. Give artificial respiration or oxygen, if necessary. Keep victim warm and at rest. Seek medical attention, if necessary.

Skin: Take off clothing soaked with liquid. Flush skin with plenty of water.

Eyes: Flush eyes with water for 15 minutes. Seek medical attention, if necessary.

Ingestion: Seek medical attention. Do not induce vomiting.

Note to Physician: Expired air analysis and urinary metabolites have been used to monitor exposure.

FIRE AND EXPLOSION INFORMATION

General: Not flammable or explosive at room temperatures. Ignites at 770°F (410°C), moderately flammable at high temperatures.

Explosive Limits: Upper - 41%, lower - 11%.

Extinguisher: Carbon Dioxide, dry chemical or foam.

REACTIVITY

Materials to Avoid: Contact with strong alkalies can form highly poisonous and explosive products.

Conditions to Avoid: Contact with certain hot metals (e.g., aluminum and magnesium), open flames or ultraviolet radiation can form poisonous or explosive products.

PROTECTIVE MEASURES

Storage and Handling: Store in sealed steel or plastic cans or dark glass bottles.

Engineering Controls: Use in well ventilated areas with no cross drafts. Sinks and showers should be available.

Protective Clothing (Should not be substituted for proper handling and engineering controls): If direct contact is likely, wear coveralls, polyvinyl boots and gloves, and goggles or a faceshield.

Protective Equipment: For up to 500 ppm use a chemical cartridge respirator with organic vapor cartridges, a supplied-air respirator or a self-contained breathing apparatus. Up to 1000 ppm use the above with a full facepiece or a gas mask with an organic vapor canister. For escape from a contaminated area use a gas mask with an organic vapor canister or a self-contained breathing apparatus.

Miscellaneous: Wash any liquid-soaked clothing before reuse. No food or smoking near liquid or vapor.

PROCEDURES FOR SPILLS AND LEAKS

Get all workers out of the spill area. Put on a respirator and other protective clothing. Spread sand or other absorbent material over liquid to absorb it. Shovel into buckets, take to a safe place in the open air. Wash area of spill with soap and water. For final disposal contact your regional office of the New York State Department of Environmental Conservation.

For more information: Contact the Industrial Hygienist or Safety Officer at your worksite or the New York State Department of Health, Bureau of Toxic Substance Assessment, Empire State Plaza, Corning Tower, Albany, New York 12237.

Occupational Health Guideline for Xylene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- **Formula:** C_8H_{10}
- **Synonyms:** Commercial xylene (xylol) is a mixture, mostly the meta-isomer. 1) O-xylene, ortho-xylene, 1,2-dimethylbenzene; 2) m-xylene, meta-xylene, 1,3-dimethylbenzene; 3) p-xylene, para-xylene, 1,4-dimethylbenzene
- **Appearance and odor:** Colorless liquids with aromatic odors (pure p-xylene is a solid below 12.7 C (55 F)).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for xylene is 100 parts of xylene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 435 milligrams of xylene per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 100 ppm averaged over a work shift of up to ten hours per day, forty hours per week, with an acceptable ceiling level of 200 ppm averaged over a 10-minute period. The NIOSH Criteria Document for Xylene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Xylene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

• Effects of overexposure

1. Short-term Exposure: Xylene vapor may cause irritation of the eyes, nose, and throat. At high concentrations, xylene vapor may cause severe breathing difficulties which may be delayed in onset. At high concentrations, it may also cause dizziness, staggering, drowsiness, and unconsciousness. In addition, breathing high concentrations may cause loss of appetite, nausea, vomiting, and abdominal pain. Liquid xylene may be irritating to the eyes and skin. Exposure to high concentrations of xylene vapor may cause reversible damage to the kidneys and liver.

2. Long-term Exposure: Repeated or prolonged exposure to xylene may cause a skin rash. Repeated exposure of the eyes to high concentrations of xylene vapor may cause reversible eye damage.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to xylene.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to xylene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, eyes, gastrointestinal tract, blood, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—A complete blood count: Xylene has been shown to cause reversible hematopoietic depression in animals. A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

—Liver function tests: Since liver damage has been observed in humans exposed to xylene, a profile of liver

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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function should be obtained by using a medically acceptable array of biochemical tests.

—Urinalysis: Since kidney damage has been observed in humans exposed to xylene, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on a biannual basis.

• Summary of toxicology

Xylene vapor irritates the eyes, mucous membranes, and skin; at high concentrations it causes narcosis. In animals, xylene causes blood changes reflecting mild toxicity to the hematopoietic system. Repeated exposure of rabbits to 1150 ppm of a mixture of isomers of xylene for 40 to 55 days caused a reversible decrease in red and white cell count and an increase in thrombocytes; exposure to 690 ppm for the same time period caused only a slight decrease in the white cell count. Three painters working in a confined space of a fuel tank were overcome by xylene vapors estimated to be 10,000 ppm; they were not found until 18.5 hours after entering the tank, and one died from pulmonary edema shortly thereafter; the other two recovered completely in 2 days; both had temporary hepatic impairment (inferred from elevated serum transaminase levels) and one of them had evidence of temporary renal impairment (increased blood urea and reduced creatinine clearance). In humans, exposure to undetermined but high concentrations caused dizziness, excitement, drowsiness, incoordination and a staggering gait. Workers exposed to concentrations above 200 ppm complain of anorexia, nausea, vomiting, and abdominal pain. Brief exposure of humans to 200 ppm caused irritation of the eyes, nose, and throat. There are reports of reversible corneal vacuolation in workers exposed to xylene, or to xylene plus other volatile solvents. The liquid is a skin irritant and causes erythema, dryness, and defatting; prolonged contact may cause the formation of vesicles.

CHEMICAL AND PHYSICAL PROPERTIES

Data in the following section are presented for xylene's three isomers: 1) ortho, 2) meta, and 3) para.

• Physical data

1. Molecular weight: 106.2
2. Boiling point (760 mm Hg): 1) 144.4 C (292 F); 2) 138.9 C (282 F); 3) 138.3 C (281 F)
3. Specific gravity (water = 1): 1) 0.88; 2) 0.86; 3) 0.86
4. Vapor density (air = 1 at boiling point of xylene): 3.7
5. Melting point: 1) -25 C (-12 F); 2) -48 C (-54 F); 3) 13 C (55 F)
6. Vapor pressure at 20 C (68 F): 1) 7 mm Hg; 2) 9 mm Hg; 3) 9 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 1) 0.00003; 2) 0.00003; 3) 0.00003

8. Evaporation rate (butyl acetate = 1): 1) 0.7; 2) 0.7; 3) 0.7

• Reactivity

1. Conditions contributing to instability: Elevated temperatures may cause containers to burst.

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving xylene.

4. Special precautions: Xylene will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Flash point: 1) 32 C (90 F) (closed cup); 2) 28.9 C (84 F); 3) 27.2 C (81 F)

2. Autoignition temperature: 1) 465 C (869 F); 2) 530 C (986 F); 3) 530 C (986 F)

3. Flammable limits in air, % by volume: Lower: 1) 1.0; 2) 1.1; 3) 1.1; Upper: 1) 6.0; 2) 7.0; 3) 7.0

4. Extinguishant: Foam, carbon dioxide, dry chemical

• Warning properties

1. Odor Threshold: Patty states that "the initial odor of 200 ppm has an intensity of approximately 3 and an irritation value of 1. As in most other instances, olfactory fatigue occurs rapidly and the odor is no longer detected at this concentration."

2. Eye Irritation Level: The *AIHA Hygienic Guide* states that "exposure to vapors at 200 ppm caused eye irritation in most of the persons tested. Lesions in the form of fine vacuoles in the cornea of cats exposed to commercial xylene vapors have been observed."

3. Other Information: The *Handbook of Industrial Organic Chemicals* states that xylene "may be irritating to eyes, nose and throat as exposure exceeds threshold limit." The *Hygienic Guide* notes that 200 ppm causes irritation of the nose and throat.

4. Evaluation of Warning Properties: Through its irritant effects, xylene can be detected within three times the permissible exposure limit. For the purposes of this guideline, therefore, xylene is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• Eight-Hour Exposure Evaluation

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of xylene. Each measurement

should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure xylene may be used. An analytical method for xylene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid or solid xylene.
- Clothing contaminated with xylene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of xylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the xylene, the person performing the operation should be informed of xylene's hazardous properties.
- Any clothing which becomes wet with liquid xylene should be removed immediately and non-impervious

clothing which becomes contaminated with xylene should be removed promptly and not reworn until the xylene is removed from the clothing.

- Employees should be provided with and required to use splash-proof safety goggles where liquid or solid xylene may contact the eyes.

SANITATION

- Skin that becomes contaminated with xylene should be promptly washed or showered with soap or mild detergent and water to remove any xylene.
- Employees who handle liquid or solid xylene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to xylene may occur and control methods which may be effective in each case:

Operation	Controls
Use as an intermediate during manufacture of plastics, synthetic fibers, and mixed/pure isomers	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use as diluent or solvent in surface coatings, printing operations, and manufacture of rubber; degreasing agent in plastics and electronics manufacture; in organic synthesis reactions and manufacture of epoxy resins	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use in formulation of insecticides	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use in manufacture of xylene-formaldehyde resins; pharmaceuticals, vitamins, leather; and as a sterilizing agent for cat-gut and in microscopy	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment

Operation

Use during blending of motor and aviation fuels

Controls

Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If liquid or solid xylene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If liquid or solid xylene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If liquid or solid xylene penetrates through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

• Breathing

If a person breathes in large amounts of xylene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When xylene has been swallowed, do not induce vomiting. Get medical attention immediately.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If xylene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a

suitable combustion chamber. Xylene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of xylene vapors are permitted.

4. If the solid form, allow to melt and treat as in (3) above.

• Waste disposal method:

Xylene may be disposed of by atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR XYLENE (XYLOL)

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
10,000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 10,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.